BIG-BOXES AND STORMWATER

A Thesis
Presented to
The Academic Faculty

by

Alexander H Fite-Wassilak

In Partial Fulfillment
of the Requirements for the Degree
Master of Architecture in the
School of Architecture

Georgia Institute of Technology
August 2008

BIG-BOXES AND STORMWATER

Approved by:

Richard Dagenhart, Advisor
College of Architecture, Architecture Program
Georgia Institute of Technology

David Green
College of Architecture, Architecture Program
Georgia Institute of Technology

Dr. Michael Elliott
College of Architecture, City and Regional Planning Program
Georgia Institute of Technology

Date Approved: July 7th 2008

ACKNOWLEDGEMENTS

I would like to thank Richard Dagenhart for being an even-keeled and involved advisor who made this whole project possible. I also wish to thank my other readers, Professor Elliott and David Green, for their feedback and patience. I owe a tremendous debt to my loving wife Amanda who endured this process with patience and grace. She sometimes had more faith in me than I had in myself and for that I will always be grateful. Last, but not least, I would like to thank my family for their support and understanding.

TABLE OF CONTENTS

LIST OF FIGURES

SUMMARY

Big-box Urban Mixed-use Developments (BUMDs) are mixed-use developments with a consistent typology that incorporate big-box retailers in a central role. They are also becoming popular in the Atlanta region. While BUMDs serve an important economic role, they also cause issues with stormwater. This study explores integrating a on-site approach to stormwater management into the design of BUMDs. These new designs not only significantly lower the amount of stormwater run-off, but also have potential for better, more attractive, developments.

CHAPTER 1

INTRODUCTION

The Rise of Mixed-Use Developments

Several mixed-use developments that include prominent big-box retailers have sprouted up in the Atlanta area over the last few years. While these developments serve an important economic role, they also have a negative impact on stormwater. Stormwater is water produced during a storm or other precipitation event; the problem occurs when water runs off the surface on which it lands, collects, and becomes a larger stream. This stormwater run-off can cause extensive damage to human and ecological communities.

The various elements inherent to Big-box Urban Mixed-Use Developments (BUMDs), such surface parking lots, large roofs, and lack of vegetated spaces, prevent stormwater from soaking into the ground, thus exacerbating stormwater run-off. Stormwater run-off in BUMDs is even more problematic since these developments use a large amount of gross area. These two factors make BUMDs significant contributors to stormwater problems.

This study explores integrating a balanced approach to stormwater management into the design of BUMDs. These new designs not only significantly lower the amount of stormwater run-off, but also have potential for better, more attractive, developments.

Defining the BUMD type

Big-box Urban Mixed-use Developments are redevelopments of underutilized sites in urban areas that, like other mixed-use projects, introduce a mix of commercial and residential programs that promise “live work play” opportunities[1]. They differ from other mixed-use developments in that the commercial uses are dominated by big-box retail, with additional commercial in the form of restaurants, offices, and boutiques. The big-box retailers are often situated off to the side, separated by their large surface parking lots. Aside from their location, these stores are indistinguishable from their suburban counterparts. The housing is present as condominiums or apartments, sometimes above retail shops, and townhouses. These pieces are generally located on the edges of the site to serve as a buffer between the big box retailers and the neighborhood. BUMDs differentiate themselves as ‘urban’ developments with a pedestrian area, often emulating small town main streets or town squares, and partially hiding the big-box elements. Developers like the Florida-based Sembler Corporation seem to have found a new paradigm in BUMDs, and are looking to propagate it.

The Popularity and Benefits of BUMDs

The popularity of Big-box Urban Mixed-Use Developments and mixed-use projects in general is evident by their frequency. In Atlanta mixed-use projects like Edgewood Retail District, Glenwood Park, Atlantic Station, and Lindberg Plaza among others have sprouted up in the last five years with others like the Park at Briarcliff and HOME at Brookwood coming on line. Of these only Glenwood Park and Atlantic Station are not BUMDs, as defined earlier. Building these developments in “under-retailed” sections of the city is quite lucrative, enough so that corporations like Sembler keep pushing a similar model [2,3]. These big-box oriented developments claim to provide

[1] TOWN Briarcliff Brochure, The Sembler Company. Retrieved 4/3/2008. http://sembler.com/pdfs/Town%20Briarcliff.pdf
[2] Edgewood Retail District Brochure, The Sembler Company. Retrieved 4/3/2008. http://sembler.com/pdfs/Edgewood%20Retail%20District.pdf
[3] Woods, W. *Unusual firm opens 'big boxes' intown; persistence, flexibility and money are key*. The Atlanta Journal-Constitution. November 12, 2006. Main Edition

"pedestrian-friendly urban village[s], built for convenience and accessibility."[4] They also claim their developments will serve as a "thriving hub of neighborhood activity for families and singles alike.[5]" These statements suggest benefits such as greater walkability and higher quality of life. However, there are aspects of these developments that do not appear so rosy.

BUMD Lineage

Though Big-box Urban Mixed-use Developments have positive aspects touted by their promoters these developments come from a suburban lineage of big-box retailers. BUMDs represent the current iteration of addressing issues concerning big-box retailers and consequently inherit some of the sins of their predecessors. Some of the concerns about big boxes in urban areas include: urban design, relation to surrounding neighborhoods, aesthetics, traffic, encouragement of automobile use, and stormwater. BUMDs try to address urban design, aesthetics, and connection to neighborhoods through a variety of techniques. Adding housing and office space is an attempt to address urban design and connection to the neighborhood; these pieces are positioned at the periphery to serve as a buffer between neighborhoods and big box retailers. Providing the pedestrian corridors and squares serves the dual role of helping to partly hide the big-box retail from view and trying to accommodate urban design concerns. Some aesthetic concerns have been addressed by wrapping all uses on site in a more traditional-looking brick façade rather than the more conventional concrete. These changes and modifications are partly successful; there is less resistance to BUMDs than big-box retailers alone. However, there still is resistance from many neighborhoods and critics.

---

[4] TOWN Brookhaven Brochure, The Sembler Company. Retrieved 4/3/2008. http://sembler.com/pdfs/Town%20Brookhaven.pdf
[5] Edgewood Retail District Brochure, The Sembler Company. Retrieved 4/3/2008. http://sembler.com/pdfs/Edgewood%20Retail%20District.pdf

Changing BUMDs to address these remaining concerns is needed. Big-box developments are unlikely to disappear any time soon; they attract large amounts of shoppers, even when neighborhoods have initially opposed them, and they are some of the largest US companies. Since big-boxes are staying put and BUMDs represent their current urban iteration, it seems reasonable to try to improve them. Environmental concerns like automobile use and stormwater runoff represent some of the major concerns that have not been addressed. Though automobile use seems a likely candidate for improvement, big box retail success is derived from people driving to shop there. The economic model set up by the developers depends on automobile use and therefore is difficult to change. On the other hand, stormwater is more closely related to physical characteristics on site and it has been well studied. Consequently, stormwater makes an excellent candidate for addressing environmental improvements as well as making BUMDs better developments.

The Importance of Stormwater Management to Developers

The biggest reason stormwater management should matter to developers is that it can be implemented to make better developments. These more appealing developments will raise fewer objections with neighborhoods and help smooth the permitting process. Holistic stormwater management uses water as a resource rather than as a waste and therefore creates a more interesting, more attractive place. The increased attention to such places may have benefits. Well-designed stormwater management in BUMDs can provide a fusion of the services and aesthetics of ecosystems with the benefits of a true urban location.

On the negative side, repercussions from poor stormwater management can have serious effects on communities and ecosystems. These effects can be divided into four main categories: flooding, erosion, water quality, and groundwater recharge.

Most importantly, large quantities of stormwater flowing quickly can increase the size of floodplains, which places human life and property at risk of floods[6]. This increase in water flow can cause erosion of streambeds and riverbanks further placing life and property at risk as well as erasing entire ecological niches.

Poor water quality is a problem because of the pollutants and trash stormwater gathers. Stormwater rushing over landscaping, streets, and parking lots absorbs several forms of pollution: organic matter, excess nutrients, microbes, heavy metals, and hydrocarbons. The initial portion of runoff can have a notably higher concentration of these pollutants; a phenomenon known as the "first flush"[7]. Poor stormwater management allows polluted water to flow into surface sources or infiltrate into the ground, which impairs drinking water supplies. As a result poor stormwater management can increase the cost of decontaminating drinking water. Additionally, polluted surface water can become too hazardous for human contact and visibly degraded, reducing the opportunity for bodies of water to be used for recreational purposes. Consequently, properties surrounding contaminated bodies of water can lose value. From an environmental perspective, aquatic species and habitats are particularly susceptible to damage from water pollution, especially from the first flush of stormwater.

Groundwater recharge is a subtler problem. Making a surface impermeable causes more water to flow over the surface than to percolate into the ground. This means that over time less water is recharging the groundwater, which leads to less groundwater flow into streams and other bodies of water. Lower water levels in streams, ponds, and lakes are not only a problem for recreation but have a large impact on aquatic ecosystems.

---

[6] Haubner, Steve, Andy Reese, Ted Brown, Rich Claytor, and Dr. Tom Debo. *Georgia Stormwater Management Manual*, 2001
[7] Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.

Poor stormwater management has significant effects on communities in terms of basic water needs, local economies, recreation, safety, and environmental quality. However, traditional methods of handling stormwater fail to adequately manage many of negative effects of stormwater. Creating developments that are more sensitive to the hydrological cycle may not only alleviate some of these negative effects, but also create better spaces.

Hydrology and Development

The Hydrological Cycle

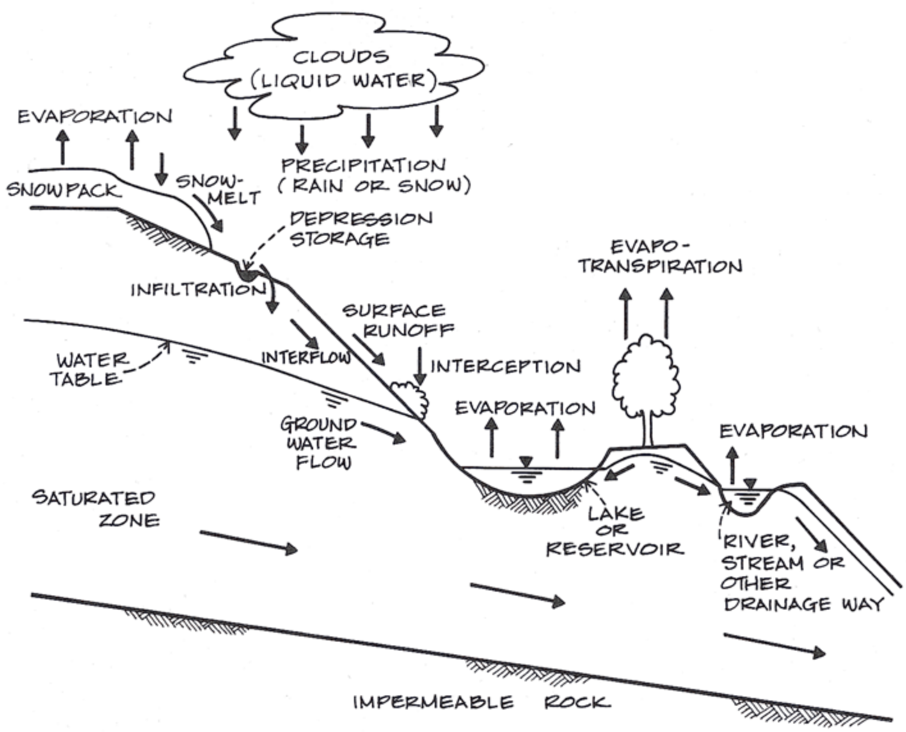


Figure 1.1: The Hydrological Cycle (from Walesh)

To understand stormwater in the context of developments, knowledge of the basic hydrological cycle is necessary. The hydrological cycle is the never-ending movement of water from one form to another (see Figure 1.1)[8]. Water evaporates off bodies of water, the ground, and transpires from the leaves of plants to become water vapor in the atmosphere. It falls again as precipitation whether as rain, snow, or hail. This water from precipitation is known as stormwater. Some water from precipitation percolates into the soil to join the ground water at the water table, a process known as groundwater recharge. The ground water then flows underground to meet streams, ponds, lakes or other bodies of water. From there it evaporates and the process starts all over again. Stormwater overflow is the portion of water that falls during precipitation but does not percolate immediately; instead it flows over ground until it meets a permeable surface or a body of water. This overland flow has some fundamental differences from sub-surface flow. Because groundwater flows through a matrix of soil, it has exposure to soil microorganisms and plants that help break down pollutants the soil itself also acts as a filter to trap these pollutants[9]. The process of flowing through the soil slows the water significantly. In contrast, overland flow has limited exposure to plant or microorganisms and its quick unhindered movement picks up pollutants rather than filtering them out. Figure 1. 2 illustrates the differences in flow between impervious and vegetated surfaces. Impervious surfaces result in a quick spike of water run off, whereas vegetated areas tend to have a more gradual increase and decrease. Notice that the area under the curve, representing the volume of water is not the same size for both curves. While the same amount of rain falls, the vegetated area soaks up and retains water. The excess stormwater largely exits the site through the slow sub-surface flow of groundwater. The impervious areas simply force the water to run off quickly. Knowledge of water processes helps clarify their relationship and importance to development. The next step is

---

[8] Walesh, Stuart. G. *Urban Surface Water Management*. John Wiley & Sons. 1989
[9] Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.

to understand how hydrological processes fit within the context of stormwater management.

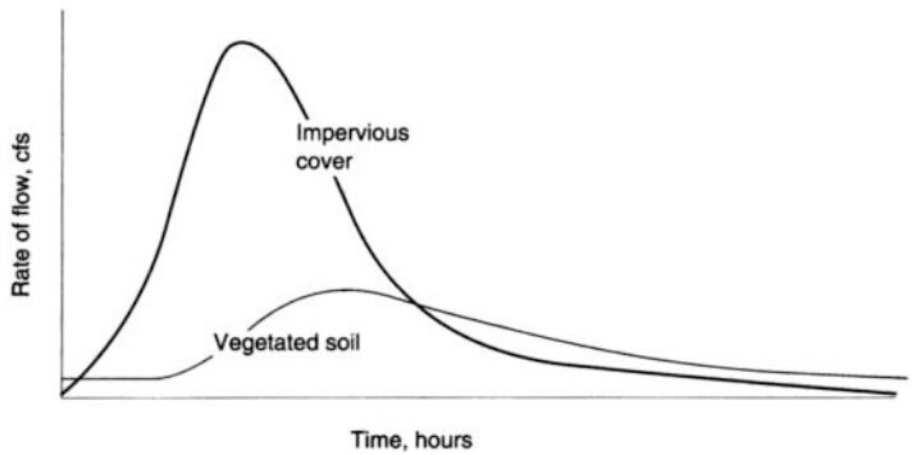


Figure 1.2: Graph of storm flow off vegetated and impervious surfaces (from Ferguson 98)

The Principles of Stormwater Management

Ferguson divides the basic processes of stormwater management into four main categories; each with its own path for accommodating stormwater[10]. They are: conveyance, detention, infiltration, and harvesting. Each will be described more thoroughly below.

Conveyance

Conveyance is the transfer of water off-site, usually through pipes or some form of conduit. Often this movement is to a body of water such as a stream or lake. Conveyance is one of the oldest stormwater techniques, used in the ancient Roman city of Pompeii, in Olmstead's Riverside development, and it was the predominant stormwater management technique in the US until around 1965[11]. It is known now that conveyance

[10] Ibid.
[11] Ibid.

has several associated issues; it does not address the stormwater problems of flooding, erosion, water quality, or groundwater recharge. However, it still serves an important role as an emergency back-up solution whenever there is a rare large storm.

Detention

Detention is the holding of water on site for a temporary amount of time. Together with conveyance they represent the dominant stormwater management principles. Detention became quite prevalent in the 1960s when the flood ramifications of urban development became evident[12]. The effect of detention is to spread the volume of water of a longer period of time to control the peak level of flow. It is this peak level of flow for which detention facilities are designed. As a result the volume of water is of secondary importance; the flow takes primary importance. Detention helps mitigate flooding and erosion if designed properly, but does not address issues of quality or groundwater recharge.

Infiltration

Infiltration is the absorption of stormwater directly into the ground. This process results in groundwater recharge. Infiltration is the most complete individual stormwater principle because it addresses concerns about erosion, flooding, quality, and groundwater recharge. However, it requires porous soils that allow adequate water to infiltrate relatively quickly. Because infiltrated water joins groundwater polluted water can cause groundwater contamination. However, measures can be taken to prevent this.

Harvesting

[12] Ibid.

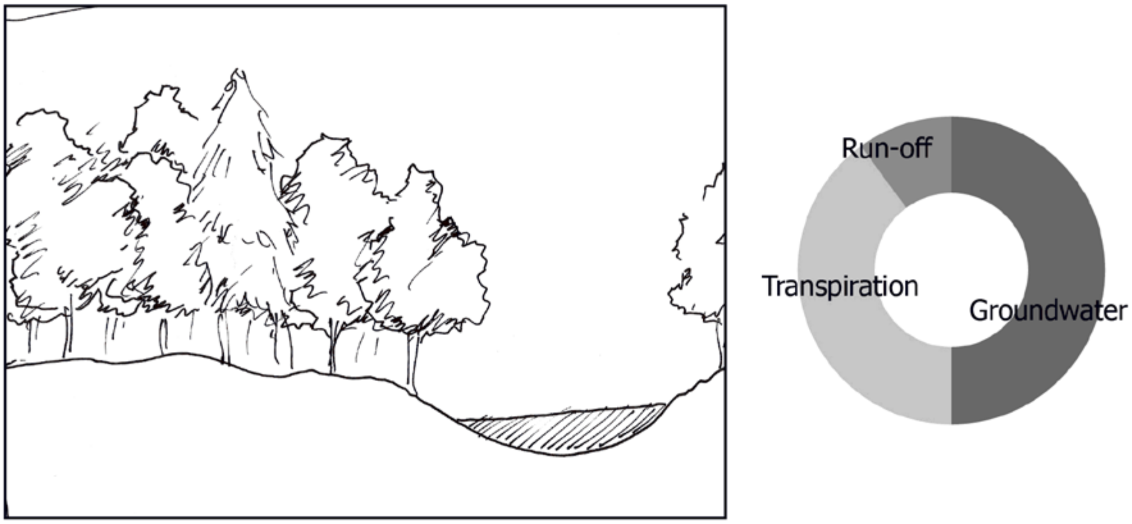
Harvesting is the direct capture and use of stormwater for a site. This principle is also an ancient practice, though in modern times it occurs in areas where water distribution systems are not completely reliable. The use of harvested water is varied. It can be easily used for non-potable uses such as irrigation or toilet flushing, but it must undergo more rigorous treatment to be used for anything involving human contact. Harvesting is not a complete stormwater solution by itself. Its ultimate fate depends on the specifics of the water use; if used for irrigation purposes it functions similar to an infiltration system and it is a complete solution. If, however, the water is just kept on site to use for toilet flushing, that water is essentially conveyed back to the municipal sewer after use.

The afore-mentioned stormwater management principles are the building blocks for an effective stormwater management system. Conventional developments tend to focus on the principles of conveyance and detention. On the other hand, a holistic model of stormwater management balances them all to minimize negative impacts. Understanding how stormwater is affected by development is the next step towards a complete view of the relationship between BUMDs and stormwater management.

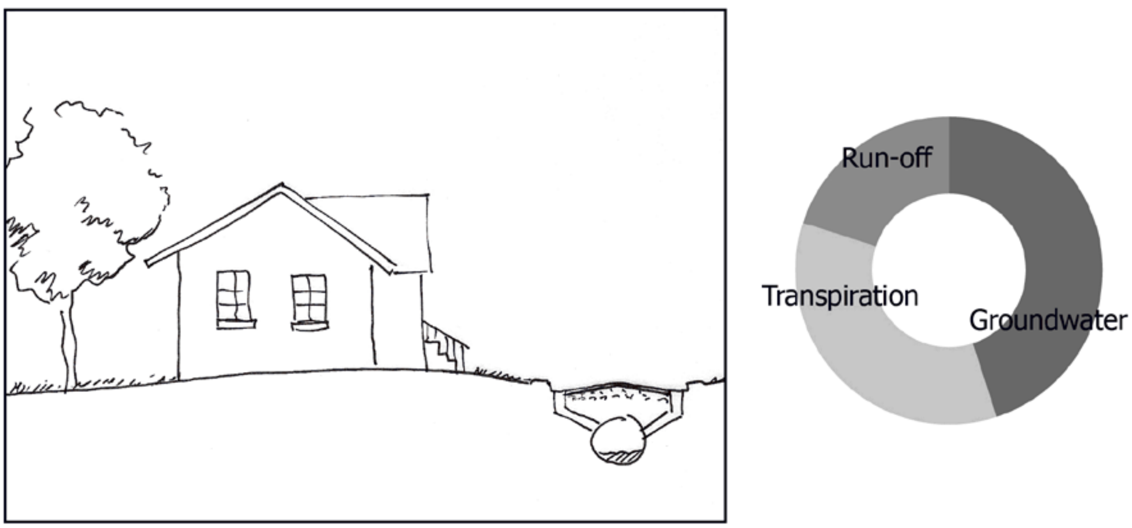
The Impact of Development on Stormwater

Development always has an impact on stormwater. To understand how stormwater management and BUMDs interact, a series of scenarios will be examined that explain how water moves in varying degrees of development. The first scenario is a forest, the second is a low-density suburban housing area, and the third is a development completely covered with impermeable surface similar to a typical BUMD.

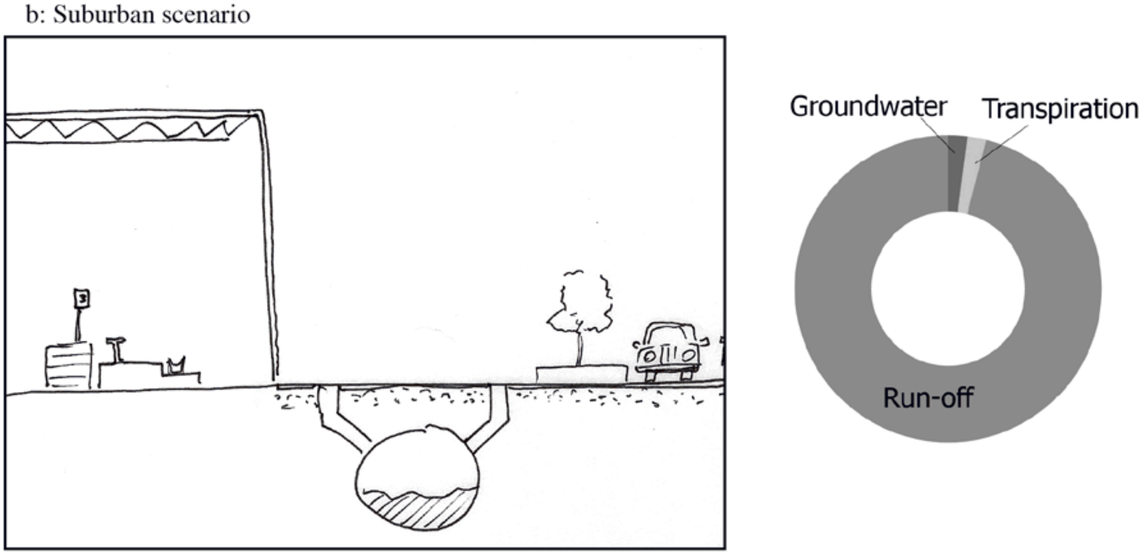
In a forest in northwest Georgia (Figure 1.3a), the majority of the water entering the hydrological cycle falls as rain. The bulk of this is absorbed into the ground. Not all of this becomes groundwater for very long. The trees, shrubs, and other plants, which have their roots in the soil, absorb it. From there it moves through the plant to the leaves



a: Forest scenario



b: Suburban scenario



c: Big-box development scenario

Figure 1.3: Stormwater Flow from Differing Development Scenarios

where it evaporates in a process known as evapotranspiration. The groundwater flows under the ground towards a nearby stream, where it becomes a part of the stream flow. The small remaining portion of water, which cannot be absorbed by the soil or is obstructed by leaves or rocks close to the surface, becomes a trickle of surface run-off. This small amount of runoff flows down to a nearby stream and pond.

In a suburban development (Figure 1.3b) not too far from the forest described above, you may have a house with a back and front yard as well as a street that provides access to the house. The house and street are impermeable, so when the rain falls, it flows off of those surfaces as run-off. Single-family houses often pipe their water over the lawn, so some of that water could be absorbed by the ground there. In the front and back lawns the grass and other vegetation would use some of the water for evapotranspiration, as would the surrounding trees. A smaller portion of the lawn water would flow over ground onto surrounding streets. That over ground flow along with any water falling on the street, would channel into the storm sewer where it would be piped directly to the nearby stream.

In the shopping area (Figure 1.3c) where the suburban family buys their groceries, there is almost no permeable surface. The entire area is either parking lot or roofs of the retailers. There are a few planters with small trees in the parking lot, but their effect is negligible. When it rains here, all the tiny pockets in the surface of the asphalt and the roof membrane absorb the first bits of water. After those tiny pockets are full, the surface is saturated and the water starts to flow off the surface. Surface saturation occurs in all environments but its effects are most noticeable in large impervious surfaces. The water from the surfaces pools and flows towards the storm drains, where it quickly flows into the local creek. The ground in planters absorbs a tiny portion of the water; the trees there transpire an even smaller portion.

Each of the four stormwater management principles is used in each of the above examples. Perhaps the hardest to see, is in the forest example. The stream serves as a conduit for conveyance, channeling extra water away from the site. The detention function is another familiar body of water, the pond. It can accommodate some fluctuations in volume, but that extra volume eventually is used or evaporated. Infiltration is most similar; water absorbs into the ground the same in a forest or a city. Finally, harvesting can be seen in the process of evapotranspiration; collected water in the soil is analogous to rainwater saved for irrigation. Each of these pieces operates in conjunction with the others. The result is a balanced system of stormwater management. The suburban and big-box development also use the same four stormwater principles but they are not balanced. Figure 1.3 shows how run-off, essentially conveyance, makes a larger portion of stormwater as development increases. The principles of stormwater management do not change, but the application of these principles changes over different development contexts. The challenge is to make big box developments more like a forest in terms of their stormwater management while keeping their economic and cultural uses.

The Link Between BUMDs and Stormwater

The generation of large amounts of stormwater is correlated with mixed-use developments due to several main components of these projects. By definition Big-box Urban Mixed-use Developments have big-box retailers as a majority of their commercial space. Big-box stores often have large space requirements that cause a two-fold problem. First, the stores tend to be predominantly single-story which results in a large impermeable roof top; second, the nature of these stores require a large amount of parking by code, despite the pedestrian focus of some of the urban developments. In addition to big-box retailers, BUMDs also favor restaurants, which also have an intensive parking requirement; in the city of Atlanta they are required to have at least one parking space per 100 square feet of space[13]. Parking tends to be in surface lots because it is the least expensive option. The surface parking covers a large portion of the site with an almost unbroken impermeable layer presenting a situation similar to Figure 1.3c. Last, parcels in any context usually have some surface water flowing onto it from off-site. In typical BUMDs, where impermeable surface is abundant, this additional water only intensifies the problem. These integral stormwater impacts make BUMDs a challenge to tackle but an important one given their popularity and size.

Conventional Solutions to Stormwater

The conventional approaches to stormwater management on-site are detention and conveyance, which have limitations that were discussed earlier. However, each individual urban site fits within a context of a collective stormwater management system. This collective management is performed through either combined or separate sewage systems. In the separated sewer system the stormwater flows in its own pipes directly to a body of water. A combined system is when stormwater joins sanitary sewage in its path to the treatment facility before it is discharged. In the combined system all the water is treated before being discharged into the receiving body of water, unless the system is overloaded. When the system is overloaded, the combined water must be discharged without treatment, this is known as a combined sewage overflow[14]. Both sewer approaches have problems associated with them. What more, their existence has allowed individual sites to rely totally on moving the water off-site. Conveyance of water off-site is necessary as a fallback during very large storms, however off-site approaches fail to

---

[13] *City of Atlanta Code of Ordinances*. Municode. 3/1/2008. http://www.municode.com/Resources/gateway.asp?pid=10376&sid=10
[14] *EPA Combined Sewer Overflows* EPA 3/25/08 http://cfpub.epa.gov/npdes/home.cfm?program_id=5

address the root of the stormwater problems. To fully address the source of the problem balanced on-site control is critical.

There are efforts to control stormwater at the site-level through city legislation. For example, Atlanta has taken some measures to address stormwater quantities including Chapter 74 Article X of the City Code of Ordinances that restricts new developments peak rate of flow to 70% of the predevelopment level[15]. This ordinance mandates that new developments reduce the peak rate of flow off the site during a storm to 30% less than what it was before development. This rate-based restriction of flow can mitigate erosion and flooding, however it still does not address the issues of pollution or ground water recharge. There can even be a reduction flow and still have in increase in overall stormwater volume.

On a site level, the conventional management of stormwater is limited largely to engineering practices; know as Best Management Practices (BMPs). While these BMPs exist expressly to address some of the conventionally neglected problems of stormwater, such as water quality and ground water recharge, they tend to be add-ons and they often focus on one stormwater principle at a time. Stormwater is not an integrated part of the design process, so the additional cost of BMPs is often viewed as external to the project. Because it is seen as an additional burden instead of an integral part of the design, these features are utilized only to reach minimum standards. A better solution is possible.

Study Process

The purpose of this study is to explore whether integrating stormwater management into the design of an urban mixed-use development can reduce the amount of stormwater shifted off-site and potentially improve the development. The first step in

---

[15] *City of Atlanta Code of Ordinances*. Municode. 3/1/2008. http://www.municode.com/Resources/gateway.asp?pid=10376&sid=10

this exploration is to examine the typical Big-box Urban Mixed-use Development. The chosen design site is the Edgewood Retail District (ERD) because it exemplifies the typical BUMD; it has a big-box component separated from the main pedestrian area, as well as redeveloping an underutilized site in an established area of in town Atlanta. The stormwater generated by the existing development will be analyzed using proven methods and compared to the preexisting conditions. Next, two alternative scenarios will be explored; each testing the limits of an alternative stormwater management principle. These designs will be detailed enough to give a schematic idea how such a development may move forward. The alternatives will then be measured for stormwater run off using the same method as for the existing development. Next, the new scenarios will be compared and analyzed against the existing development to identify salient differences. This analysis will lead to a series of conclusions and suggestions for how new big-box oriented developments to address stormwater more effectively.

CHAPTER 2

THE STUDY SITE

Overview

The last chapter described how developments like Big-box Urban Mixed-use Projects (BUMDs) cause dysfunctional hydrological cycles. This chapter establishes Edgewood Retail District as a typical BUMD and examines the conditions of the site before and after the development to establish a baseline for comparison with designed alternatives.

Edgewood Retail District as typical Big-box Urban Mixed-use Development

To adequately test alternative stormwater principles on Big-box Urban Mixed-Use Developments (BUMDs) a suitable study site is required on which to experiment. The Edgewood Retail District (ERD) meets all the criteria for a BUMD. Like other BUMDs it features a strong focus on big-box retailers including national chains like Target and Lowes. It also shows another aspect of BUMDs, the pedestrian oriented “main street.” This pedestrian area does not connect very well to the big-box retailers; the large surface parking lots prevent that. The surface parking is another typical characteristic of BUMDs. In addition, the site is a formerly underutilized urban site surrounded by established neighborhoods. To better understand the site and context of alternative designs, this chapter will examine the pre-existing conditions, the development of ERD, and its stormwater performance before and after the development.

Predevelopment and Site History

The study site is located on the eastern edge of the City of Atlanta in DeKalb County as seen in Figure 2.1. More specifically it is located on the intersection of the CSX railroads and Moreland Avenue in the Edgewood neighborhood. The neighborhoods

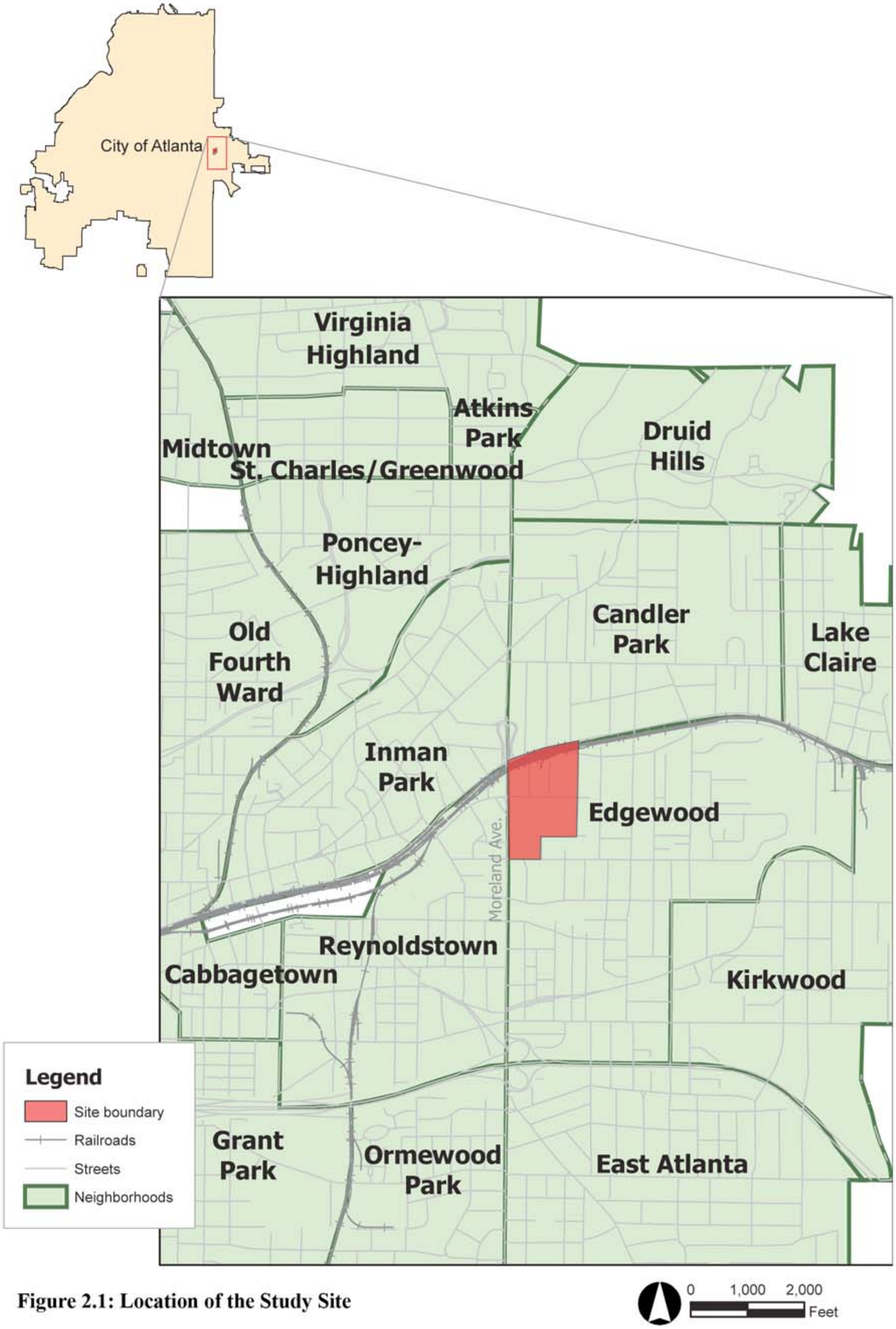


Figure 2.1: Location of the Study Site

of Inman Park, Candler Park, and Reynoldstown surround the area and each was involved with shaping the new development. Prior to being developed into the ERD, the site belonged to Atlanta Gas Light, who used it mostly for storage and maintenance. The 2000 Aerial photograph in Figure 2.2 shows the site was covered with a variety of different buildings, large amounts of parking surrounding many of them. The area to the northeast notably has a lot of open vegetated space and there are several smaller islands of vegetation dispersed throughout the site.

From an urban perspective the pre-developed site does not seem like it is part of a city at all. The jumble of properties makes it appear like there are no property lines. The streets are few, instead there are thoroughfares through parking lots. The streets present, aside from Caroline Street, are dead-ends and had been abandoned by the city. These streets hardly look to be decent public space. The only available public spaces are the vegetated areas in the northeast and southwest corners, both of which look shabby and inhospitable from the aerial photograph.

Hydrological Features

There are four main components that determine the site's place in the hydrological cycle: topography, watershed, soil type, and ground coverage. The site's topography is one of predominantly gradual slopes facing south. The high point is the northeast corner of the site; from there it gradually slopes southwest. This is evident in Figure 2.3 which shows the topography before the Edgewood Retail District was developed. The site seems to slope down in all directions toward the southwest corner to the former location of Sugar Creek, which is now partly piped underground. This is evidence that the site is located in a former creek bed. This fact may pose a problem regarding the amount of water flowing from off-site. The watershed locates the sites within the larger context of grander water cycles. The site is located on the edge of two different watersheds: the Upper Chattahoochee and the Upper Ocmulgee, each names

Figure 2.2: 2000 Aerial Photograph of Study Site

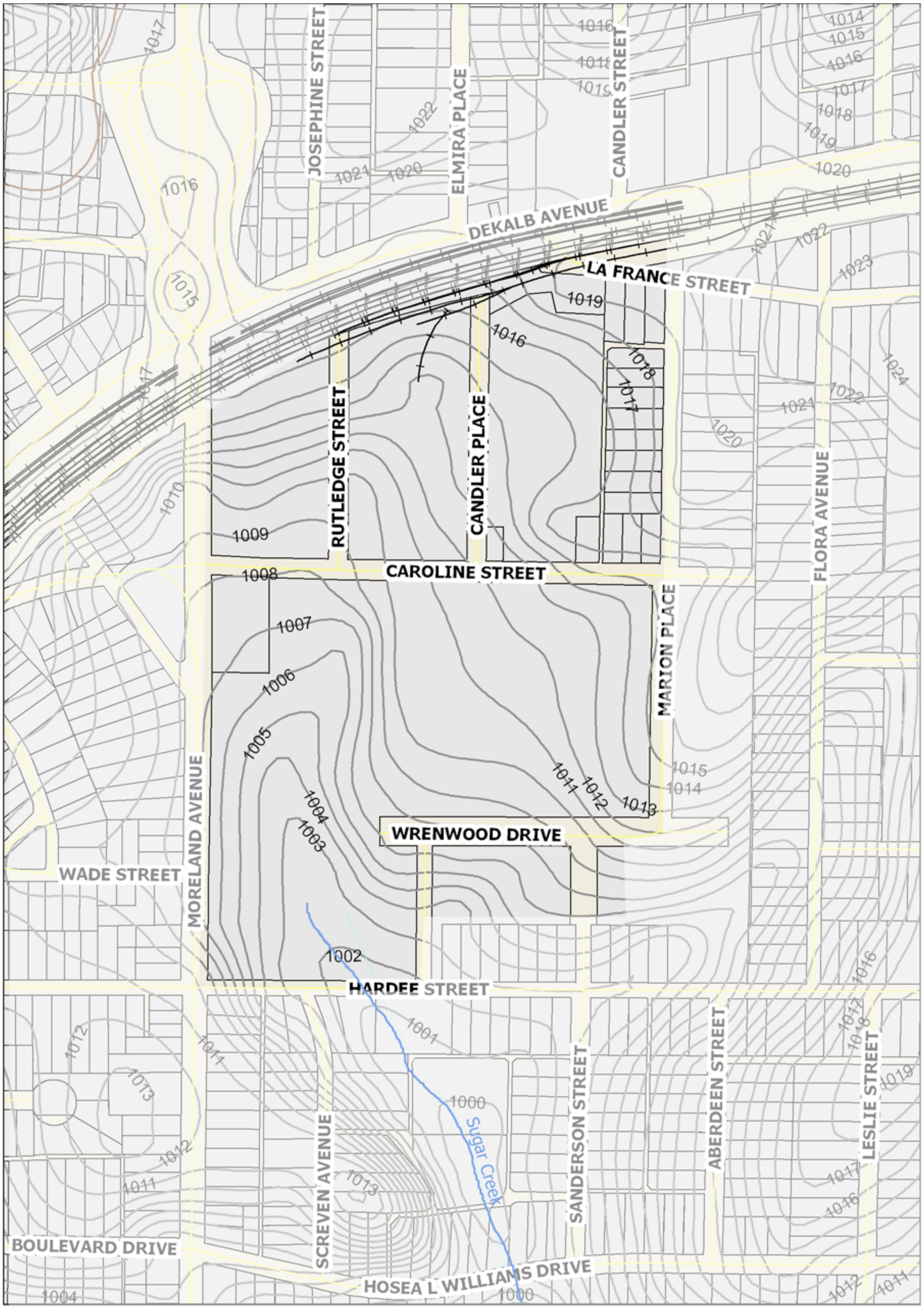


Figure 2.3: Pre-Existing Topography and Block Structure

after the rivers into which they flow. Figure 2.4 shows the site (in red) relative to the two watersheds. The green line that runs along the railroad to the north of the site is the boundary between the two. Any water landing on the site eventually makes its way to the Ocmulgee River, via Sugar Creek, which has been annexed as part of the storm sewer. The slight complication of this arrangement is that the site, as a part of Atlanta, receives its municipal water from the Chattahoochee River, via Lake Lanier. If municipal water were used for landscaping or otherwise not leave the site via the sanitary sewer, the water would not return to its original source.

The soil type is another important contributor to the hydrological performance of the site. Data from National Resource Conservation Service soil surveys can be seen in Figure 2.5. The diagram shows that the Cecil and Pacolet soil series surround the site. Both the Cecil and Pacolet series are considered to be well drained and capable of percolating water moderately due in part to a sandy loam top layer[16,17]. According to the City of Atlanta Stormwater Manual, the sandy loam found in Cecil and Pacolet series has an infiltration rate of 1.02 inches/hour, which triples the infiltration minimum they suggest, 0.27 inches, for infiltration applications[18]. The site itself is given an urban designation in the soil survey likely because it was urbanized at the time of the survey. Since the urban designation tells us little about the soils permeability, it is assumed that the soil is similar to the surrounding soils. The soils were not tested directly, but it appears from reliable data the soils are at least moderately drained.

---

[16] *Official Series Description- Cecil*. US Department of Agriculture. 3/1/08. http://www2.ftw.nrcs.usda.gov/osd/dat/C/CECIL.html

[17] *Official Series Description- Pacolet*. US Department of Agriculture. 3/1/08. http://www2.ftw.nrcs.usda.gov/osd/dat/P/PACOLET.html

[18] City of Atlanta. *City of Atlanta Stormwater Management Design Manual*, 1996

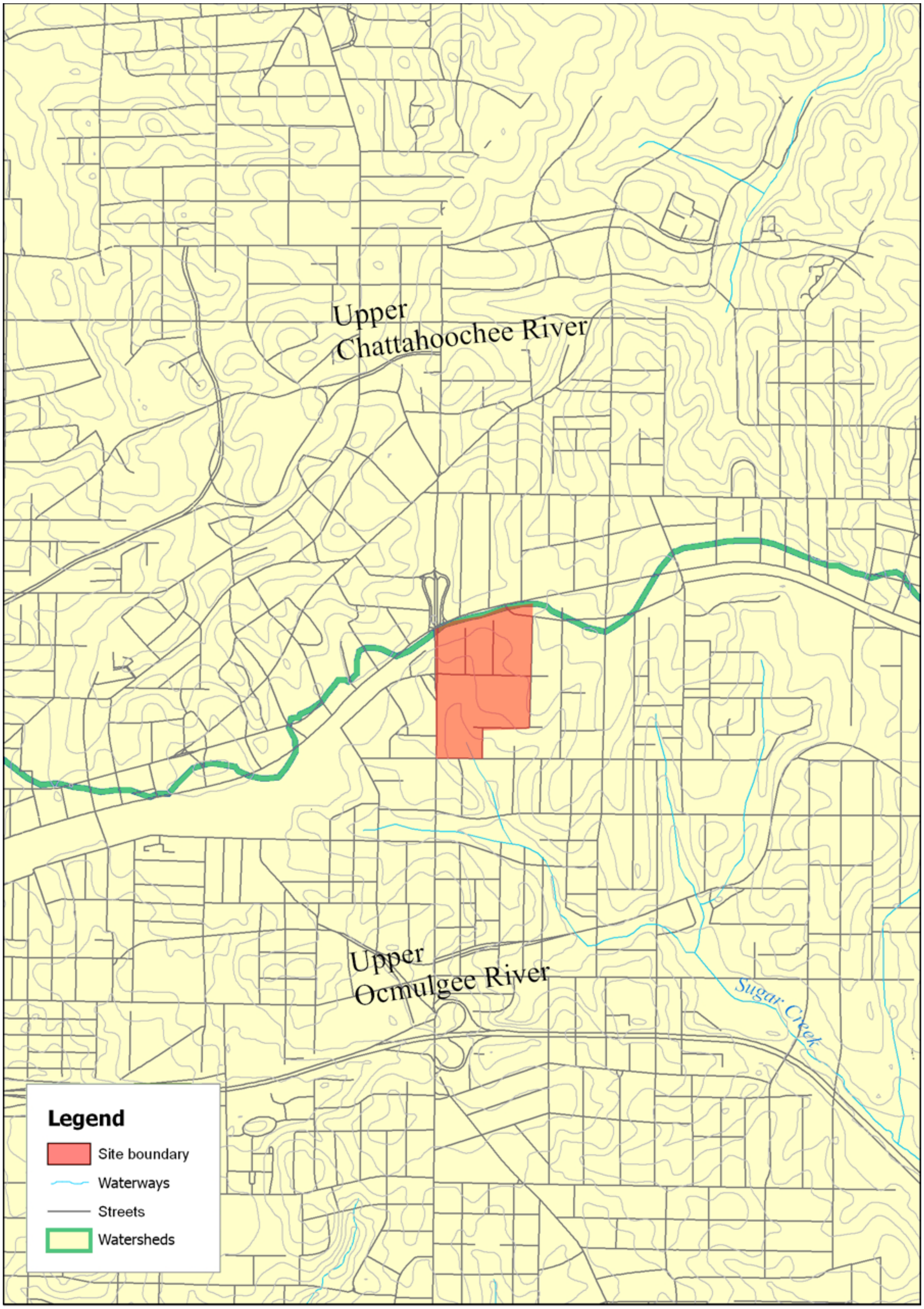


Figure 2.4: Location of Site relative to Nearby Watersheds

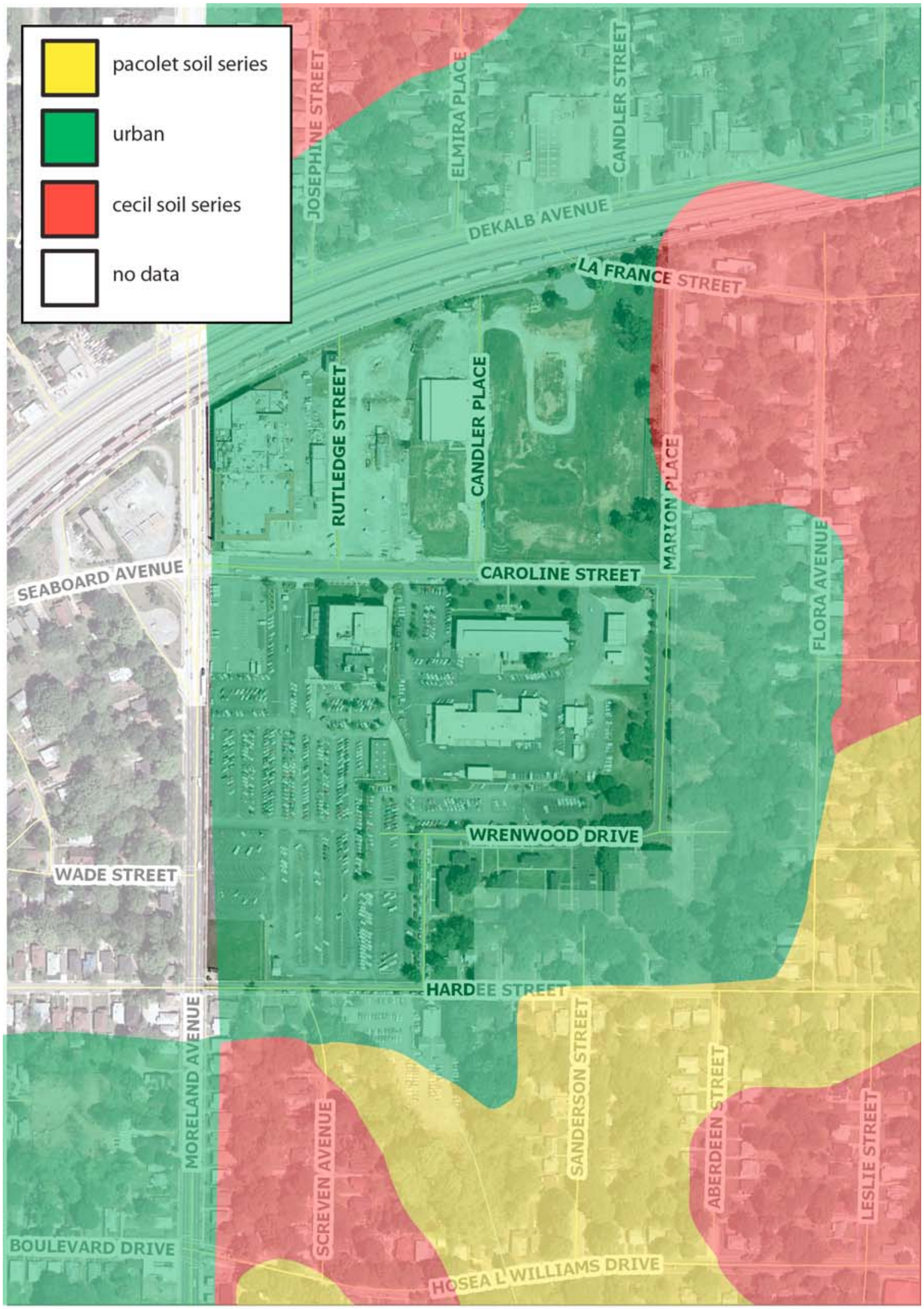


Figure 2.5: Soil Series Types for Study Site (from NRCS data)

The land coverage is the last main contributor to hydrological performance, as it can disrupt the hydrological cycle despite the underlying soil type or slope. Figure 2.6 shows much of what the aerial shows, however the coverage is shown more clearly. The portions of the diagram shown in dark gray are parking lots, the light grey represents rooftops, the green is vegetated areas, and unfilled areas are roads. A glance at the diagram shows the permeable area (shown in green) makes up a small minority of the whole site. The rest is an almost unbroken impermeable layer. The effect of this unbroken impermeable layer is that stormwater will not be able to absorb and will continue on its path to the lowest point.

All the hydrological criteria discussed above will be used later in the chapter to calculate the stormwater flows generated by the pre-big-box configuration. This will then be compared to the ERD as developed.

Development of Edgewood Retail District

Development Process

It was the Florida-based Sembler Corporation that transformed the Edgewood site into a big-box mixed-use project. The process of putting suburban-style big-box retailers into a site wedged between four formidable neighborhoods was not a simple one. From the beginning, it seemed the surrounding neighborhoods were opposed to the traffic as well as the notion of big-boxes near them[19]. Not surprisingly Sembler had a series of negotiations and discussions with the various neighborhoods. In the end, it was something of a back and forth. The site was zoned C-3, which allowed the developer to place a number of uses that would seem objectionable to the neighbors. Though the

---

[19] Woods, W. *Unusual firm opens 'big boxes' intown;persistence, flexibility and money are key*. The Atlanta Journal-Constitution. November 12, 2006. Main Edition

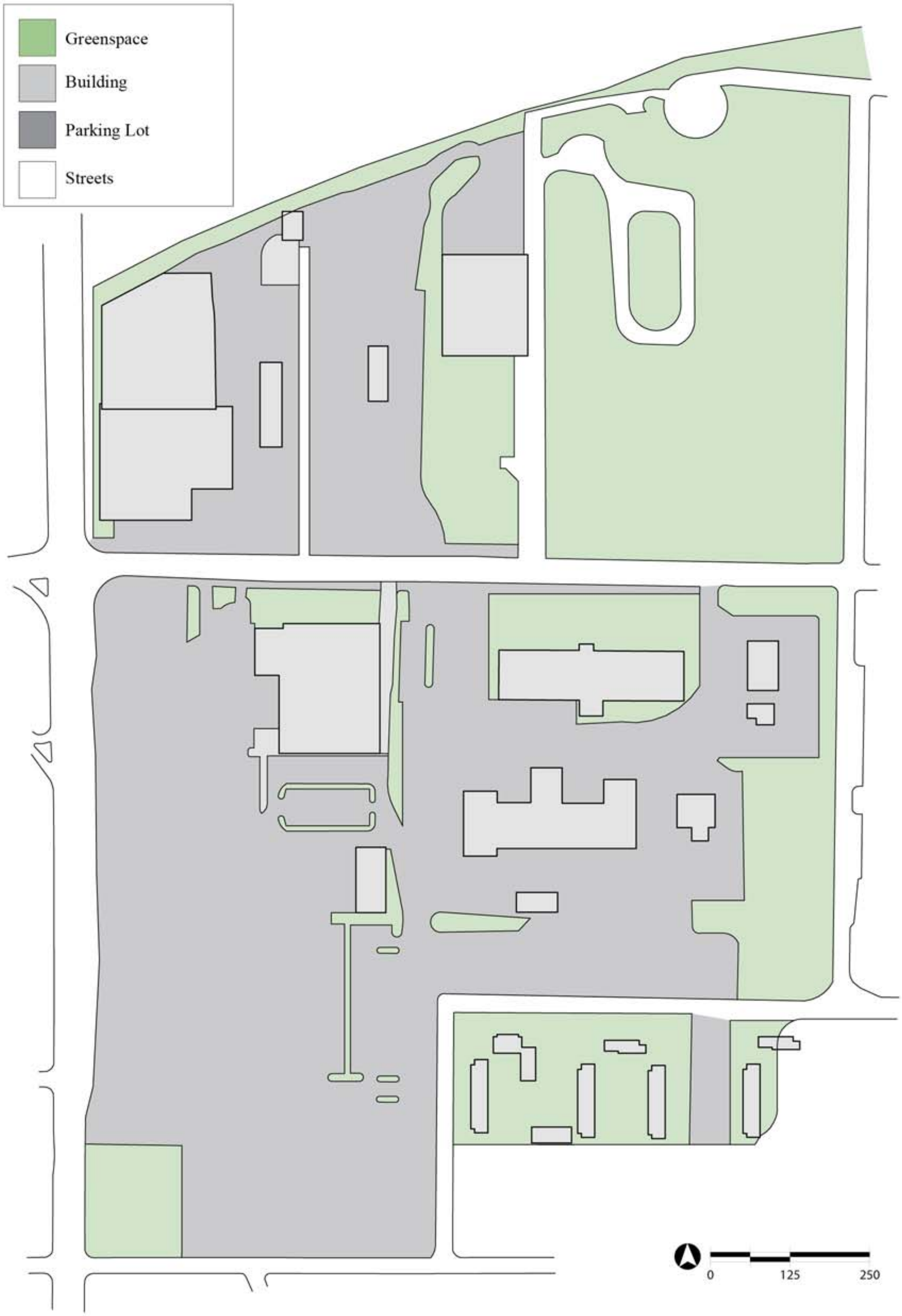


Figure 2.6: Pre-existing Site coverage for Study Site

developer held significant power it conceded to a list of demands from the neighborhood groups to facilitate city approval. Some of these demands included additional housing units, senior housing, renovation of the Shoe Factory building, office space above retail locations, and the reduction of overall commercial space[20,21]. In addition the developer gave $200,000 to neighborhood groups for the construction of a park and funded $500,000 worth of traffic calming measures[22,23]. The end result is that the surrounding Neighborhood Planning Units all approved the development and the approval passed unanimously through the City Council[24]. The mayor herself was present at the opening of the project.

Edgewood Retail District Site Strategies

Sembler's redevelopment of the site opened in 2005, showing many of the traits now associated with Big-box Urban Mixed-use developments. There were few large design moves that shaped the site, all of which can be seen clearly in Figure 2.7, which also shows the program location and square footage. One of the main moves was to make Caroline Street the pedestrian corridor. The second main move was to place the big boxes on either side of Caroline Street; Lowe's to the north, Target to the south. The third move was to turn the areas in front of either anchor to the north and south into parking 'pools', with the remaining larger developments like Kroger and Best Buy sharing these pools. The boutiques and restaurants occupy Caroline St. The last move was to place housing

[20] Woods, W. *Unusual firm opens 'big boxes' intown;persistence, flexibility and money are key*. The Atlanta Journal-Constitution. November 12, 2006. Main Edition
[21] Pendered, D. *Inman Park vows to fight Edgewood mixed-use plan*. The Atlanta Journal-Constitution. March 3, 2003. Home Edition
[22] Woods, W. *Unusual firm opens 'big boxes' intown;persistence, flexibility and money are key*. The Atlanta Journal-Constitution. November 12, 2006. Main Edition
[23] Pendered, D. *Inman Park vows to fight Edgewood mixed-use plan*. The Atlanta Journal-Constitution. March 3, 2003. Home Edition
[24] Woods, W. *Unusual firm opens 'big boxes' intown;persistence, flexibility and money are key*. The Atlanta Journal-Constitution. November 12, 2006. Main Edition

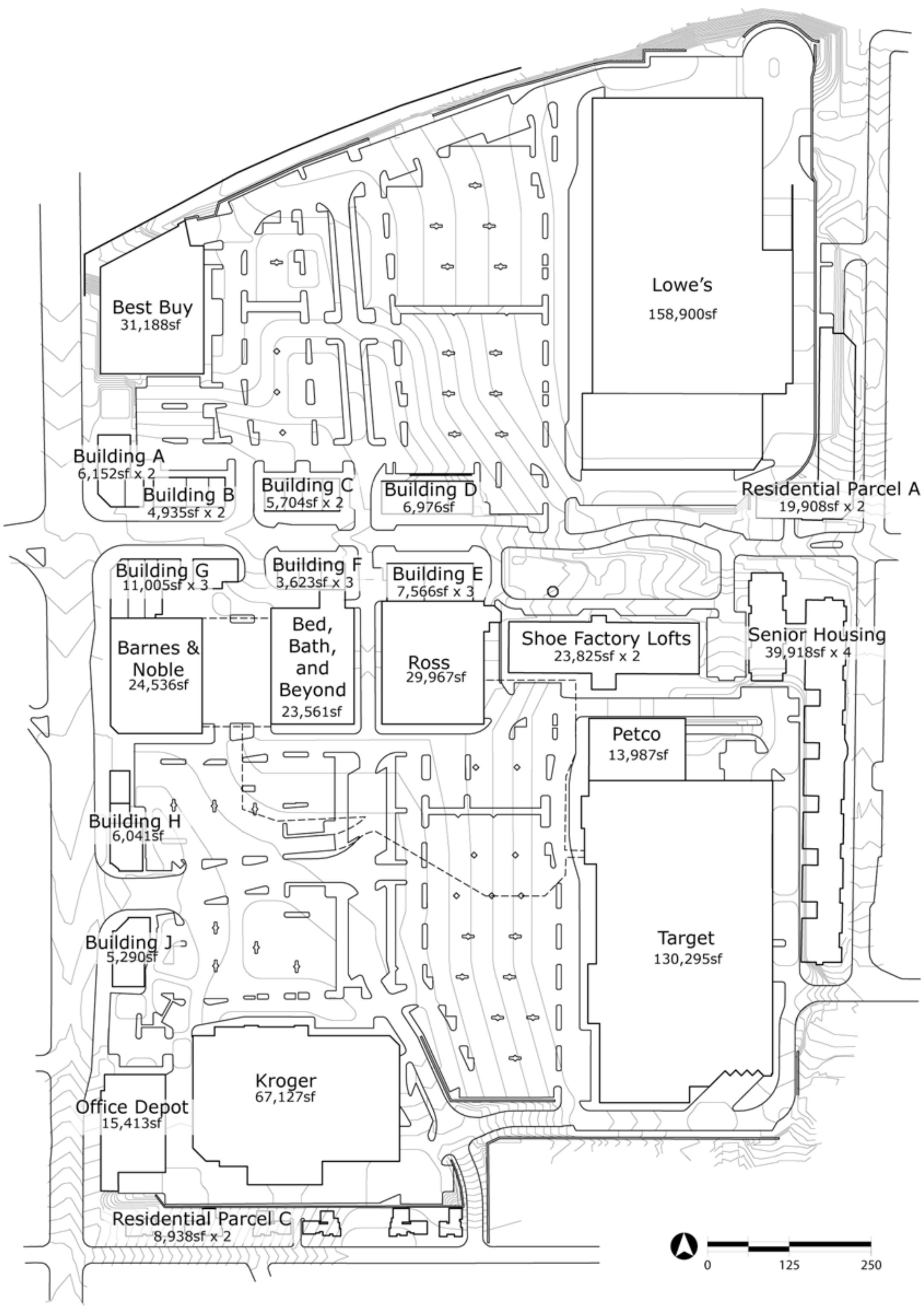


Figure 2.7: Edgewood Retail District Program Diagram

around the periphery of the development near single-family houses. All of the design moves at ERD are fairly typical for BUMDs. Understanding the implications of the individual pieces on stormwater is the next step to evaluating the effectiveness of the ERD development.

Individual Aspects of ERD

Each of the design moves and decisions for the site has ramifications on the site's hydrology and stormwater, which will be examined below.

Perhaps the largest component affecting stormwater management on the site is nearly invisible. The site has two underground detention basins in the parking lot just east of Best Buy (see Figure 2.8). The detention ponds restrict the stormwater flow rate off the north side of the site to be slightly less than the pre-existing development on its path of Sugar Creek[25]. In contrast, the stormwater from the south side flows directly to the creek without the benefit of detention. Atlanta's stormwater restriction ordinance was not applied in this development, the development only tried to restrict maximum flow to that before ERD development, without the 30% reduction. These detention facilities serve their role in restricting some of the stormwater flow, but do not alleviate the original impact of the pre-existing development.

The Big-box component of the site has not changed relative to its suburban counterpart. They look indistinguishable (see Figure 2.9a) with the same large footprint and parking requirement. Target, Lowes, Kroger, and others all are present in single-story format, presenting a large proportion of surface that is impermeable. This area relies entirely on conveyance to serve its stormwater needs. Conveyance is further utilized by

---

[25] Edgewood Retail District North Tract Hydrology Study. Robertson Loia Roof, Alpharetta Georgia. Job 02-206 November 19, 2003 revision.

Figure 2.8: Edgewood Retail District Storm Sewer and Detention Facility

piping water from the roof directly into the storm sewer (see Figure 2.9b), which feeds directly into Sugar Creek.

In concert with the big-box retailers, is the associate parking. The parking pools are quite glaring in the site plan shown in Figure 2.7, taking up a large portion of the site. However, there is more to the picture. Some of the parking is located underground and there is a small 3-story parking deck between Barnes & Noble and Bed, Bath, and Beyond (see Figure 2.9c and Figure 2.9d respectively).

a: Indistinguishable from suburban development


b: Roof drains flow directly to storm sewer


c: Entrance to underground parking


d: Multi-story parking deck

Figure 2.9: Edgewood Retail District Site Pictures and Details

This is not the typical BUMD response of surface parking. Both the underground parking and the parking deck have the potential to free additional land area for more permeable land uses. Assuming that the amount of parking would be the same with or without multi-level parking, the stormwater generated can be reduced somewhat. However, there is still plenty of stormwater generated by parking lots that is conveyed to the nearby creek.

a: Pedestrian corridor from street

b: Pedestrian corridor from parking deck

c: Streetscape with planting strip and furniture

d: Odd sidewalk condition

Figure 2.10: More Edgewood Retail District Site Pictures and Details

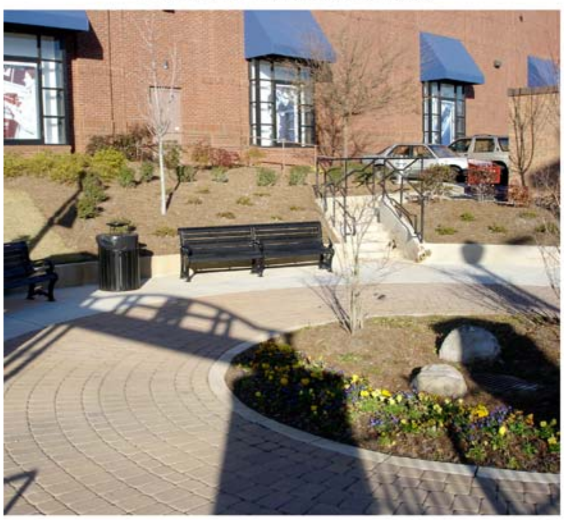
The pedestrian corridor is another typical piece of the BUMD development. It involves a fairly clear break from the rest of the development. The pedestrian feeling is created through the surrounding multi-story buildings forming a more enclosed space with retail on the ground floor (see Figure 2.10a&b). It is further enhanced by a

Figure 2.11: 2007 Aerial Photograph of Edgewood Retail District

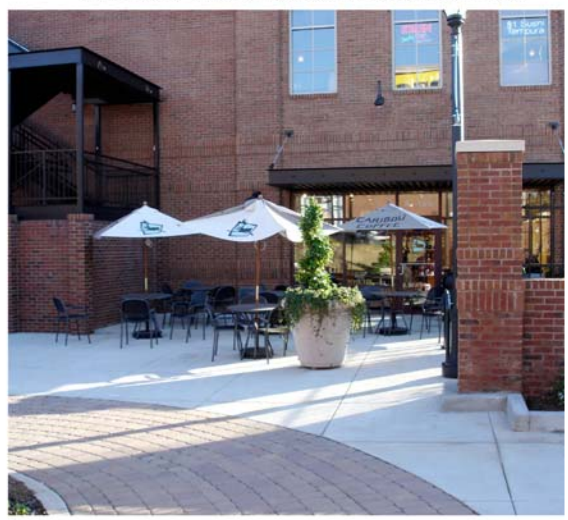
streetscape with planting strips and street furniture (see Figure 2.10c), though it does also have some bizarre topographical conditions where the sidewalk seems excessively complicated (see Figure 2.10c). Taking a cue from older developments the retail is topped with housing units along the corridor. The streets themselves are relatively narrow, consisting of two lanes with on-street parking on either side.

a: Small lawn in front of lofts

b: Another view of loft lawn from Caroline St.



c: Small planted space looking toward Best Buy



d: Small planted space looking toward Caribou

Figure 2.12: More Edgewood Retail District Site Pictures and Details

The planting strips play a small role in allowing some infiltration and harvesting, through the harvesting aspect is hardly maximized. The narrowness of the streets is good from both a stormwater and pedestrian perspective; it facilitates street crossing and reduces impermeable surface.

It is evident from the aerial photograph shown in Figure 2.11 that there is little in the way of greenspace in the development. The two main pieces are the lawn in front of the Shoe Factory Lofts and a small plaza in between the Best Buy and Caribou Coffee (see Figures 2.12a&b and 2.12c&d respectively). Both feel slightly like leftover pieces of land and are frequently desolate. The lawn in front of the Shoe Factory lofts seems to be more of a front lawn for that piece of property rather than public space. Despite their perceived function, from a stormwater perspective these serve a small role in infiltrating some of the water falling on-site.

Urban Overview

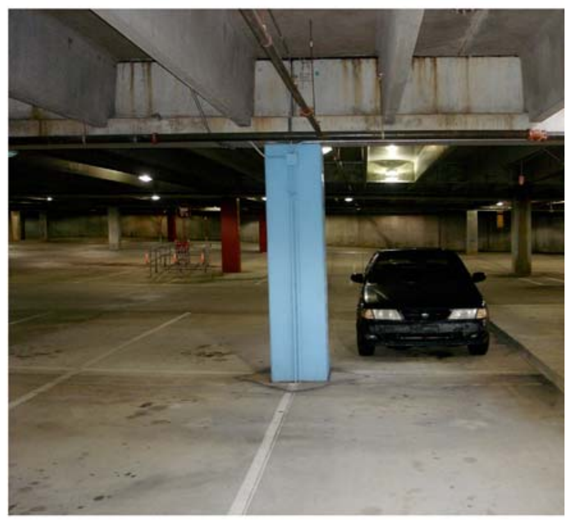


Figure 2.13: Pictures of Edgewood Retail District's Desolate Underground Parking

The Edgewood Retail District from an urban design standpoint is overall a better development than the mass of parking lots that preceded it. However, this is not much of an endorsement. The addition of a pedestrian corridor does not exactly make the entire development 'urban'. Though the pedestrian corridor is a step in the right direction, it does not even cover the majority of Caroline Street. The north side boutique retail faces both the corridor as well as the big-box parking, which is awkward. The new site is better organized, however there are still few real streets. Like the previous site, thoroughfares in parking lots serve the transportation function of streets. Though the underground parking is a boon, it is hardly ever used, even in summer when patrons may want to cover their cars (see Figure 2.13). The large parking pools cannot be ignored. Traversing such a lot by foot is not only unpleasant but also dangerous. Though the site has come a long way from its initial conditions, it has a way to go before it can claim to be a "thriving hub of neighborhood activity.[26]"

Stormwater Analysis

The SCS Method

After examining the pieces of both the pre-existing and current development, a stormwater analysis can now performed. The volume of stormwater generated can be calculated using the Soil Conservation Service (SCS) Method as detailed in Appendix A. The SCS method was pioneered starting in the 1950s by the organization of the same name, now the National Resources Conservation Service, in a largely rural context. It is a relatively simplistic model that was not designed for urban environments, but it is relatively easy to apply. The SCS method is commonly used by developers, local governments, and engineers for quick answers and has been corroborated by observed data. The SCS method is used instead of the Rational method for the simple reason that the SCS method calculates volume versus flow. Volume calculations are more important for on-site management techniques such as infiltration, harvesting, as well as detention.

[26] Edgewood Retail District Brochure, The Sembler Company. Retrieved 4/3/2008. http://sembler.com/pdfs/Edgewood%20Retail%20District.pdf

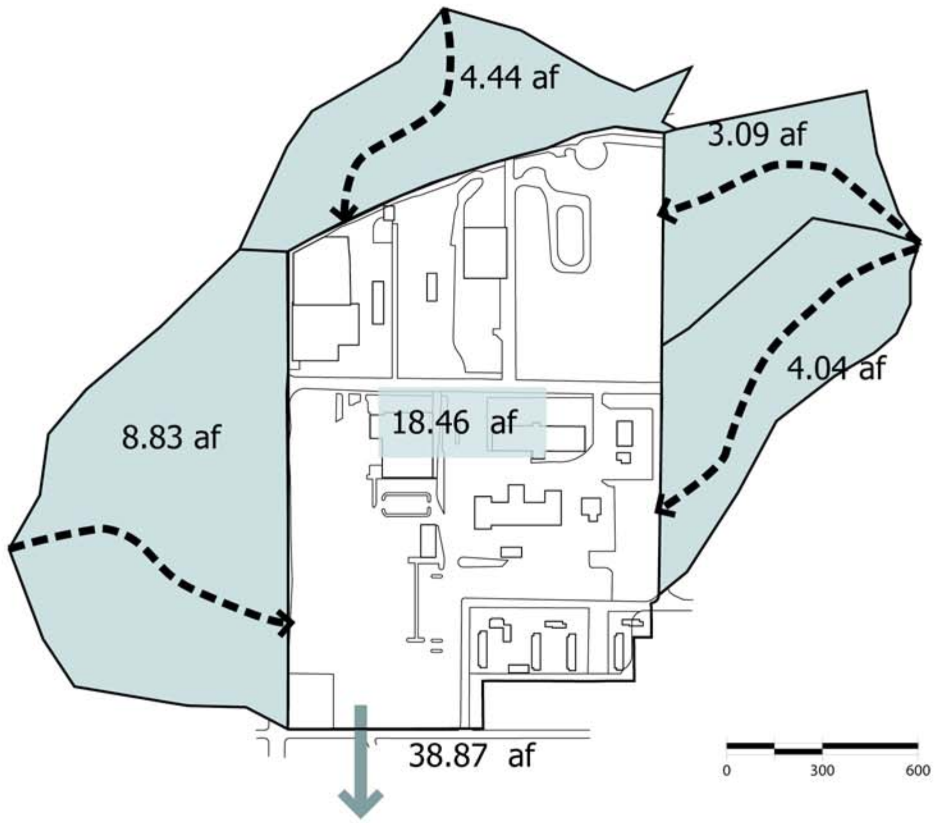
All the necessary hydrological conditions including those needed for the analysis were examined earlier in the chapter. To use the SCS method the ground cover and the Hydrological Soil Grouping (HSG) are needed. The HSG is a measure of the soil permeability. In the case of the Edgewood site, the soils series are both classified as HSG type 'B', which signifies moderate infiltration rates. The soil grouping and ground cover is used to find the curve number, which is an index for how much water will run off a given piece of land. The higher the curve number, the less permeable the ground; they range from 98 for impervious surfaces to 20 for oak-aspen mountain brush on high infiltrating soils with greater than 70% ground cover[27]. The last important piece is the design storm. Ferguson defines a design storm as "a particular combination of rainfall conditions for which you estimate and design a drainage system."[28] The design storm is usually named by its recurrence; the 25-year storm is the storm whose rainfall quantity occurs on average every 25 years based on historical records. The curve number together with the design storm is used to derive the quantity Q_d: the depth (in inches) of stormwater runoff per square foot of surface particular to that design storm and curve number. Having reviewed the process and pieces of the SCS method, the analysis can proceed.

Stormwater Overview

The results from the 25-year stormwater analysis can be seen in Figure 2.14 for the pre-existing development and in Figure 2.15 for ERD. The results are fairly intuitive; the pre-existing development generates less volume than the newer development. This is in part due to the nearly 14 acres of vegetated areas that were replaced with impermeable parking and roof space. The pre-developed strategy, despite its unassuming appearance,

---

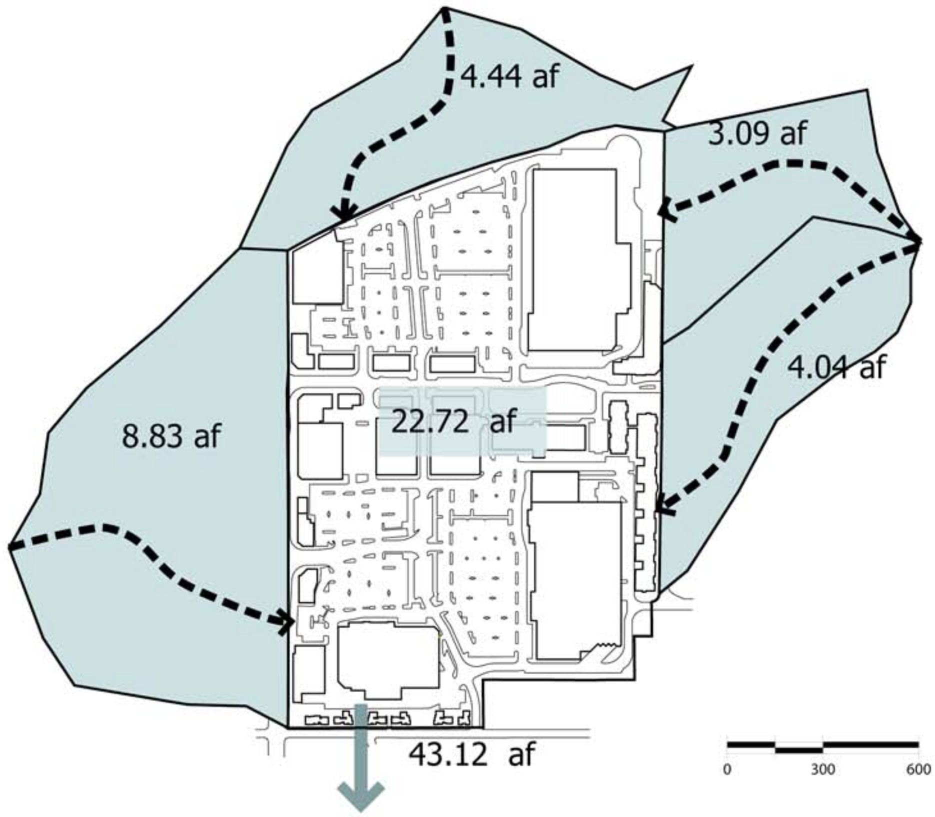
[27] Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.
[28] Ibid.



Pre-Existing Development

name	drainage area(sf)	acres	Curve #	Qd	Volume (af)
rooftops	216,852	4.98	98	6.24	2.59 af
streets & sidewalks	152,657	3.50	98	6.24	1.82 af
green space	603,621	13.86	61	2.33	2.69 af
parking	951,077	21.83	98	6.24	11.36 af
subtotal	1,924,207	44.17			18.46 af
off-site drainage					
west drainage	926939	21.28	87	4.98	8.83 af
north drainage	466555	10.71	87	4.98	4.44 af
northeast drainage	324760	7.46	87	4.98	3.09 af
southeast drainage	424492	9.74	87	4.98	4.04 af
subtotal	2,142,746	49.19			20.41 af
grandtotal	4,066,953	93.36			38.87 af

Figure 2.14: 25-year SCS Calculations and Diagram for Previously Developed Site



Edgewood Retail District

name	drainage area(sf)	acres	Curve #	Qd	Volume (af)
rooftops	543,180	12.47	98	6.24	6.49 af
streets & sidewalks	0	0.00	98	6.24	0.00 af
green space	34,439	0.79	61	2.33	0.15 af
parking	1,346,588	30.91	98	6.24	16.08 af
subtotal	1,924,207	44.17			22.72 af
off-site drainage					
west drainage	926,939	21.28	87	4.98	8.83 af
north drainage	466,555	10.71	87	4.98	4.44 af
northeast drainage	324,760	7.46	87	4.98	3.09 af
southeast drainage	424,492	9.74	87	4.98	4.04 af
subtotal	2,142,746	49.19			20.41 af
grandtotal	4,066,953	93.36			43.12 af

Figure 2.15: 25-year SCS Calculations and Diagram for Edgewood Retail District

had a more balanced stormwater strategy than the existing development. Despite the fact that current development has a detention facility that restricts flow to the previous level, the volume of stormwater has increased. This illustrates that flow and volume are not necessarily directly related. Only two of the four stormwater management principles are used at ERD. The consequence of this is that a large volume of water is generated, 43.12 acre-feet. Considering that the site is 44.17 acres, that amount is nearly enough water to cover the entire site with one foot of water. If that volume of water were stored inside the largest building in the development, the Lowe's, it could create a pool 11'-10" deep, see Figure 2.16.

Figure 2.16: Illustration of the volume generated by ERD during a 25-year storm

The water generated off-site is also quite high; in both scenarios almost as much water is generated off-site as on-site. This same volume of off-site water will be a part of every scenario and complicate the responsible management of stormwater. Building in a streambed has its price.

Site Analysis Conclusions

Edgewood Retail District (ERD) represents a typical Big-Box Urban Mixed-use Development (BUMD) as it possesses the normal traits; national big-box chains, large surface parking lots, pedestrian areas, and lack of green space. As such it serves as an appropriate test site for alternative BUMD site design. The design of ERD, which resulted from a negotiation process with surrounding neighborhoods, places a pedestrian-oriented street down the middle with large big-box retailers circled around two large parking lots one to the north and another to the south. The large amount of impermeable surface in this configuration only exacerbates stormwater issues. Stormwater volumes for the 25-year storm were calculated with the Soil Conservation Service (SCS) method. The results show that ERD produces more water volume than the previous development, though it uses an underground detention pond to maintain the same rate of flow. This fact highlights that conventional management techniques do not address the root causes of stormwater. Stormwater management on the site is completely dependent upon conveyance and a small amount of detention; the use of infiltration or harvesting is largely inconsequential. The next chapter looks at examples of alternative stormwater management techniques as inspiration for how BUMDs may be improved.

CHAPTER 3

STORMWATER APPROACHES

Overview

The last chapter examined the conditions of the study site, both before and after becoming a Big-box development. In both cases the stormwater management was skewed towards conveyance, with little regard for greater potential. This chapter first surveys innovative stormwater tactics that look promising for balancing stormwater management in a BUMD context. Next, it explores examples of these tactics in an overall strategy for a spectrum of contexts. Both strategies and tactics will inform the design of alternative BUMD configurations.

Promising Tactics for BUMDs

There are a large amount of techniques and tactics for dealing with stormwater; the list of techniques is narrowed here to tactics that could address some of the imbalance in stormwater treatment for big-box developments. Each of these techniques will be explained with the corresponding stormwater management principle, as well as its relation to BUMDs.

Infiltration basins are the first technique to discuss, representing the much underutilized infiltration principle. These basins are usually shallow depressions that allow water to rest long enough to infiltrate into the surrounding soils. Local legislation usually mandates that basins infiltrate the stored water within 24 hours. Like other infiltration systems these have some caveats. The first is that contaminated water or water with many suspended solids should be filtered first or avoided to prevent groundwater contamination and clogging. The second is that soils need to be porous enough to infiltrate a minimum amount to use this approach effectively. The last is that infiltration systems need a back up system, such as a conveyance system, to prevent flood damage from very large rainstorms. Infiltration areas are not always landscaped, but benefit aesthetically when they are. The promise with this approach is that infiltration areas can be used for other purposes such as park space. In such a case, the basin serves as a fusion of both harvesting and infiltration. The land requirements for this approach are not negligible. A large enough patch of open land, such as a park, would be required to apply this to a BUMD.

Filter strips are a simple technique of using landscaping to filter water. Rather than a depression, filter strips are simply vegetated areas on a gentle slope. As water passes though it some pollutants are left behind and biodegraded. A grassed lawn is adequate for performing this function, but the planting can be more involved and varied. Technically, filter strips serve a harvesting role, since the vegetation planted there uses some of the stormwater. However, they are better suited to managing water quality. Even in this function they simply assist, they cannot serve as the only treatment regime. Filter strips are a relatively simple technique that could easily be incorporated with existing landscaping on BUMD sites to help pretreat water.

Bioretention uses landscaped or planted areas to connect with the hydrological cycle. At a minimum bioretention areas require a filter strip, a ponding area, mulch, planting soil, and vegetation[29]. These areas help remove sediments and break down or filter pollutants so are often used to address water quality concerns. They also detain water for a short duration. In an ideal circumstance bioretention areas can also infiltrate water. However, stormwater from areas of concentrated pollution, also known as hot spots, should not be treated by bioretention. Since big-box developments have plenty of surface water that requires filtration, bioretention areas could easily find a use, even if only used to delay and ameliorate stormwater. They can be incorporated in a variety of

[29] Haubner, Steve, Andy Reese, Ted Brown, Rich Claytor, and Dr. Tom Debo. *Georgia Stormwater Management Manual*, 2001

vegetated areas with adequate depth for ponding. Planting strips and parking islands are good candidates for bioretention sites in big box developments. However, this tactic has wider applications that could also be of interest.

Another landscaped option is the enhanced swale, which allows water to run along a vegetated and pervious open swale. The benefit of this system is that while being conveyed, there is some infiltration, harvesting, and purification occurring. Because open swales take up space and are a safety concern, they do not appear to be compatible with urban areas. However, greenspace in BUMDs could incorporate enhanced swales as a more balanced and aesthetic way to convey water.

Green roofs, like filter strips and bioretention areas use the biological activity of plants and their associated soils to delay and treat stormwater. Green roofs fall into two basic configurations: extensive and intensive. Extensive systems use small drought tolerant species and shallow growth media, resulting in a thin light layer that does not usually require irrigation or large supporting structure. Intensive green roofs are usually grass, shrubs, and even trees planted on roofs that can also support pedestrian access. The consequence is heavier roof structure requirements and irrigation as well. Considering that BUMDs have massive amounts of roof space, there is ample opportunity for deployment with minimum disruption. While extensive roofs are a good solution, using intensive roofs to integrate green roofs into a more interesting synthesis of stormwater management and urban design is preferable.

Stormwater Ponds are permanent pools complete with vegetation that persist year round. They are designed to have a permanent pool level as well as a temporary storage area above the permanent level to accommodate the addition of stormwater[30]. Often additional storage is present to accommodate rare large storms. Stormwater is treated

[30] Ibid.

through a mixture of biological activity in the pool and settling. In addition to water quality services stormwater ponds provide, they assist with detention and can serve as a popular aesthetic feature to the landscape. The size requirements make urban placement difficult, but creative uses with green space could result in a working urban system in an urban big-box development.

Constructed Wetlands is a technique that uses large designed areas incorporating marshland and ponds to infiltrate, detain, and treat stormwater. In an urban context, their use is limited due to their space requirement and the need for a reliable source of water. The smaller options available are pocket wetlands and pond/wetland systems[31]. Pocket wetlands must be excavated down to the water table to maintain water levels, whereas pond/wetland systems have a pond system that drains to a shallow wetland to maintain moisture levels. Wetlands serve a very important role in normal ecosystem water management; when incorporated into site strategies they serve the stormwater infrastructure role as well as creating an aesthetic experience and wildlife habitat. The challenge with implementing a constructed wetland on a big-box site is to find the appropriate amount of space, but its benefits are multi-fold.

Multipurpose detention is a simple but powerful tactic that involves detaining stormwater on specially designed impermeable surfaces such as roofs and parking lots. These areas do not actually treat the stormwater; they simply slow the release of water to a more manageable level. This reduced flow allows the possibility for connection with other tactics such infiltration basins for a complete on-site stormwater solution.

Cistern-based harvesting involves the use of a large storage cistern to detain stormwater until its use is required. Other harvesting systems provide space-hungry ponds to serve the same function. However, using a buried or aboveground cistern this

[31] Ibid.

technique is more space-efficient, though more costly. Either system if well considered could serve a role in big-box development stormwater management.

The last stormwater tactic is the use of multi-story programming and parking. Though this tactic is not strictly a stormwater management technique, it can have large stormwater ramifications. Its effect depends on the how the reduced footprint is used. Keeping the amount of program constant, building multi-level buildings and parking lots allows for more land area to be dedicated to open space or other permeable layers. Though, quantities of stormwater can be managed, the prevention of stormwater run-off makes on-site management easier and less costly. This strategy aims squarely at the surface parking and single-story buildings prevalent in Big-box Urban Mixed-use Developments. If it can be justified, building upwards can prevent a large amount of stormwater, while allowing for the possibility of creating a more urban environment.

Each of the above tactics helps mitigate some of the negative impacts of stormwater, but none of them is a universal solution. They become more useful and elegant if used in concert, balancing the strengths and weaknesses across tactics. Different tactics linked together to create a more cohesive strategy is known as treatment 'trains'[32]. These strategies, if integrated into the design of projects, can help create more positive environments that also help manage and treat stormwater.

Stormwater Examples

The following projects each show one or more of the tactics listed above, linked into a greater strategy. These projects however vary in their size and context, from the urban intervention of Boston's Green Necklace to the detail of Portland's Green Streets Program. These examples are presented in order from the least apparently urban to the

[32] Ibid.

most urban. In each case the tactics and strategy will be discussed, especially with regards to how they may inform BUMD design.

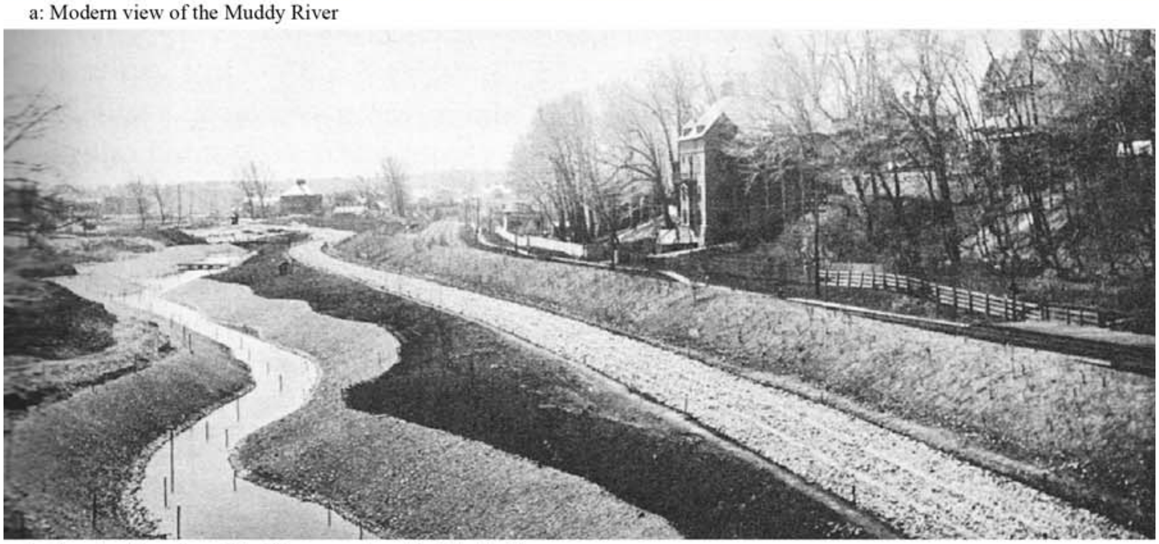
The Emerald Necklace; Boston MA.

Boston's Emerald Necklace is Frederick Law Olmstead's plan and subsequent execution of a system of greenspace to control flooding, reduce pollution, provide for the possibility of future development, and secondarily to provide park space[33]. The vast project took nearly twenty years from 1878-1896 and involved number sub-projects including many of Boston's best-known parks[34]. Of interest is the strategy used by Olmstead to handle the excessive flow of water. In the subproject of the Back Bay Improvement Olmstead constructed an artificial salt marsh to handle the brackish water coming from the Charles River. He graded the sides of the Muddy River to allow for a large change in volume with only a few feet change in the water level, see Figures 3.1a&b for the visual effect of the grading process. Walkways and trolley lines were added as well, to allow for access and enjoyment of the space. The most important aspect of this project is that it was considered foremost to be water infrastructure by its designer. Olmstead objected specifically to the use of the word "park" to describe the Fens, he preferred instead to call it a sanitary improvement.[35] This is a concrete demonstration that, at least on a city scale, water infrastructure can be appropriated as meaningful and aesthetically pleasing public space. Much has changed in the intervening century, but some of the space has not been totally altered as seen in the view of the Muddy River in Figure 3.1a. While a single big-box development cannot be expected to undertake such a large project, it does have significance for smaller projects. Creating greenspace that is

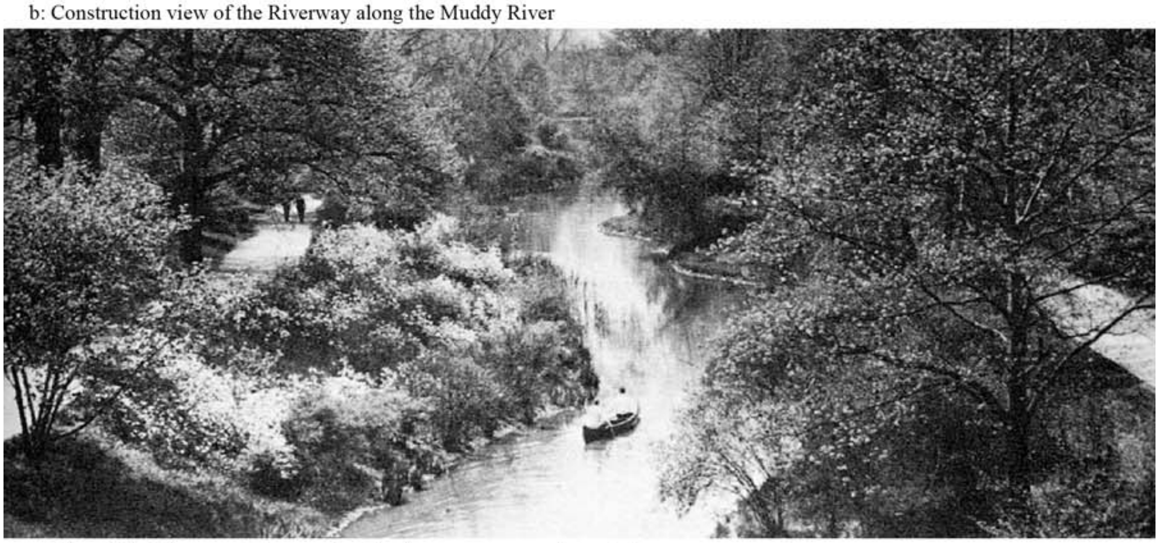
---

[33] Spirn, Anne Whiston. *The Granite Garden: Urban Nature and Human Design*. Basic Books, 1985.
[34] Zaitzevsky, Cynthia. *Frederick Law Olmstead and the Boston Park System*. Harvard University Press. 1982.
[35] Spirn, Anne Whiston. *The Granite Garden: Urban Nature and Human Design*. Basic Books, 1985.

a: Modern view of the Muddy River



b: Construction view of the Riverway along the Muddy River



c: View of the Riverway 30 years after development at approximately the same spot as above

Figure 3.1: Views of the Emerald Necklace Project (from Spirn)

infrastructure first and public space second helps incubate interesting and lasting places. The impact of the design is crucial; both the infrastructural and recreational aspects must be a consideration in the design process from the start. Secondarily the project leverages the water quality improvement capabilities of marshes, enhanced swales, and detention to control both flooding and pollution. This process is at a large scale, but it none-the-less creates a more balanced strategy of stormwater management by including detention, harvesting for landscapes, and concern for water quality.

Westergasfabriek; Amsterdam, Holland

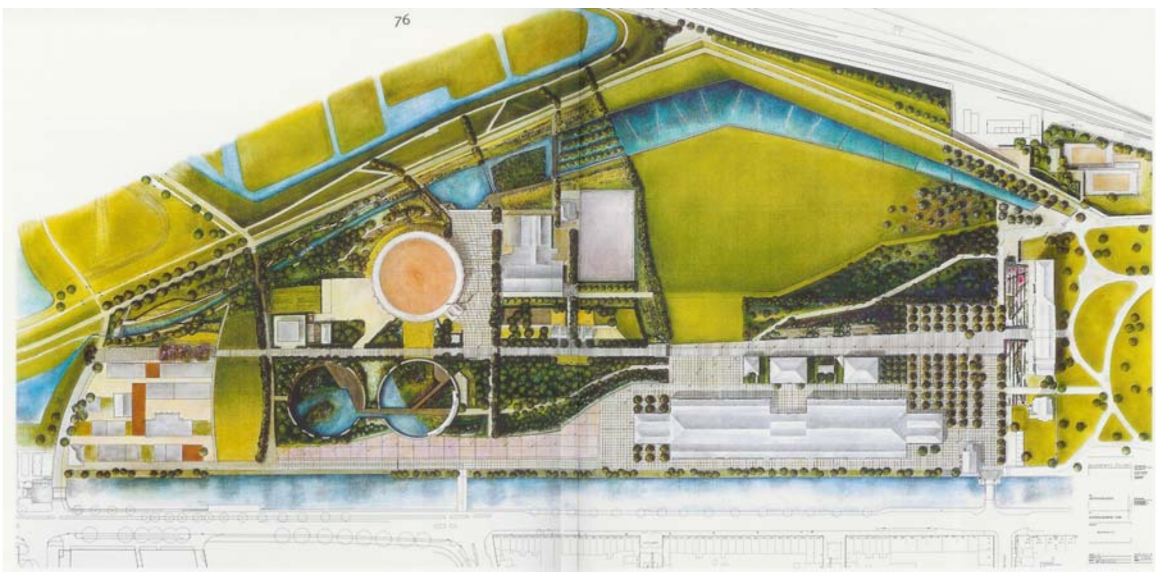


Figure 3.2: Westergasfabriek Illustrative Plan

The Westergasfabriek Culture Park is a 50-acre industrial gasification center turned modern park[36]. As an industrial brownfield redevelopment it had significant

[36] Metz, Tracy. *Amsterdam Converting Former Gasworks into a Cultural Park and "Creative" Developments*. Architectural Record. January 22, 2004.

difficulties in cleaning up the site contamination, though the project was finally completed in 2005 in the configuration shown in Figure 3.2[37].

Though the area is seldom labeled a stormwater project, there is a strong theme of water that runs throughout the project and it incorporates several stormwater tactics. The most obvious piece is the ribbon of water along the north edge of the site that starts on the east side as a wading pool (Figure 3.3a) and progresses westward through marsh areas into a seemingly wild creek. The site incorporates several stormwater control tactics into its design. Starting upstream, the grassy area surrounding the wading-pool serves as a filter strip, pretreating any water washing off the bike path toward the pool. Further downstream the design incorporates a constructed wetland in the marsh areas (Figure 3.3b), which again filters and purifies the water. Near the area of the wetland waterfall pictured in Figure 3.3b, some of the stormwater is diverted to the gasholder stormwater pond on the south side of the site, seen in Figures 3.3c&d[38]. The check-dams and vegetation along the wild-growing areas of the stream to the west serve as an enhanced swale that filters, aerates, and detains the water as seen in Figures 3.3e&f. This staging of tactics results in an effective treatment train that cleanses stormwater as it flows and allows for extra water to be handled gracefully. Direct application to BUMDs seems difficult given the project is a landscape. However, managing stormwater in an integrated strategy that ties into the purpose of the space is applicable in any project.

Victoria Park; Sydney, Australia

Like Westergasfabriek, Victoria Park is a redeveloped industrial site; however it is not just a park, it is a whole 59-acre mixed-use development including 6.5 million

---

[37] Varro, Frank. *Westergasfabriek Park*. http://courses.umass.edu/latour/2007/varro/index.html retrieved 12/07

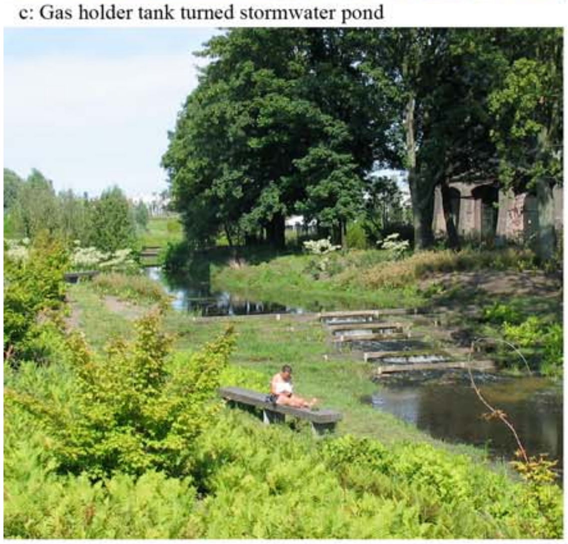
[38] Ibid.

a: Sunbathers and children along the wading pool

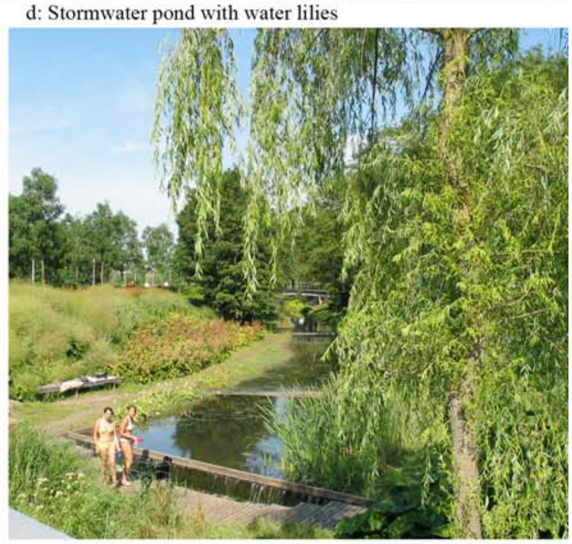
b: Bridge over water ribbon by constructed wetland

c: Gas holder tank turned stormwater pond

d: Stormwater pond with water lilies



e: Sunbather enjoying a quiet moment by the enhanced swale



f: Enhanced swales used for recreation

Figure 3.3: Stormwater Elements from Westergasfabriek

square feet of residential and retail space. The site was a former car manufacturing plant, though the design harks back to the site's earlier stage as swamp and lagoon. As a collaboration involving the government development agency, Landcom, and the Government Architect's office there was a focus on restorative water management, which became a central theme throughout the site.

Figure 3.4: Site Plan and Diagrams for Victoria Park

The site plan in Figure 3.4 shows that despite the high-density development the site focuses on several areas of greenspace, shown as dark green. Each of these serves an infrastructural role as well as a recreational role. The water management scheme revolves around the central park, which serves as a storage and cleaning solution for all the site stormwater[39]. The park includes a detention basin, constructed wetland, and storage cistern so that the development's water is contained, treated, and stored for use in water features and irrigation. These pieces are integrated as part of the park; there is a boardwalk over the wetlands and detention basin as seen in Figure 3.5c that allows pedestrians to experience and enjoy even those infrastructural portions of the park. The rest of the scheme integrates with the central park through a series of bioretention medians along the east-west streets, shown as light gray in the plan and as a photograph in Figure 3.5b. The streets on either side of the medians are sloped towards the center, with a saw-toothed curb that allows water to flow into the vegetated depression. The median serves multiple functions as both an infiltrating bioretention area, and as an enhanced swale. The medians are designed to handle the 5-year storm through infiltration; larger events flow through a series of check dams to inlet pipes that lead to the central park detention area. The check-dams and inlet pipes are cleverly hidden underneath pedestrian bridges across the medians. Some of the other green spaces seen on the plan serve mostly as grassed infiltration basins, as in Figure 3.5a, with overflow going to the central park.

This project serves as a great example of integrating several stormwater tactics into a coherent strategy. This strategy is even more impressive for its integration with open space and urban location. Though the project does not deal with the large land and parking requirements of big-box retailers, it does serve as a taste for the kind of positive development that addresses stormwater and urban conditions. Fitting large amounts of

---

[39] Weirick, J. *Watering Sydney*. Architecture Australia. 2004 Jan.-Feb., v.93, n.1, p.78-85

a: Grass-planted infiltration basin and park

b: View of street bioretention area with pedestrian bridge and saw-toothed curb

c: Pedestrian boardwalk over edge of retention basin and wetland

Figure 3.5: Photographs of Victoria Park Demonstrating Stormwater Strategies

stormwater-generating parking into such a plan would be the challenge to designing a similar BUMD.

Delft Library; Delft, Holland

The Delft Library in Holland serves as an example of utilizing green roofs for more than just stormwater management. Like all green roofs, the library uses a blend of infiltration, harvesting, and detention to purify, delay, and lessen the water running off it. What makes the project notable is that this piece of stormwater infrastructure is tilted for use as inhabitable public space. The pictures in Figure 3.6 show how the green roof can be used for public enjoyment. This suggests applications for developments where roofs can dual duty as integral pieces of stormwater infrastructure as well as contributing to the public realm. Both of these are aspects are needed in big-box projects, so inhabitable green roofs are certainly an option for BUMDs.

Figure 3.6: Delft University Library's inhabitable intensive green roof

Klaus Building; Atlanta, GA

The Klaus Advanced Computing Building on the Georgia Institute of Technology campus is a recent example of harvesting as well as bioretention in action. The building can be seen in Figure 3.7a, with the bioretention areas on either side of the center staircase. The building stores excess stormwater run-off from the roof and site in an underground cistern under the retention areas. Water from the roof and landscaping is channeled into a vegetated bioretention area shown in Figures 3.7b&c. The overflow from the bioretention area is collected in two underground cisterns totaling a little over half an acre-foot[40]. This harvested water is used for irrigating the landscaping on site, and has been used in other areas on campus too[41]. Any additional water over what the cisterns can hold is channeled into the municipal sewer system. Though this system is only a single building, it demonstrates that even urban sites can use the landscaping they have to infiltrate and harvest water for later use. Big-box Urban Mixed-use Developments can make use of that lesson to help mitigate some of their prodigious stormwater impact.

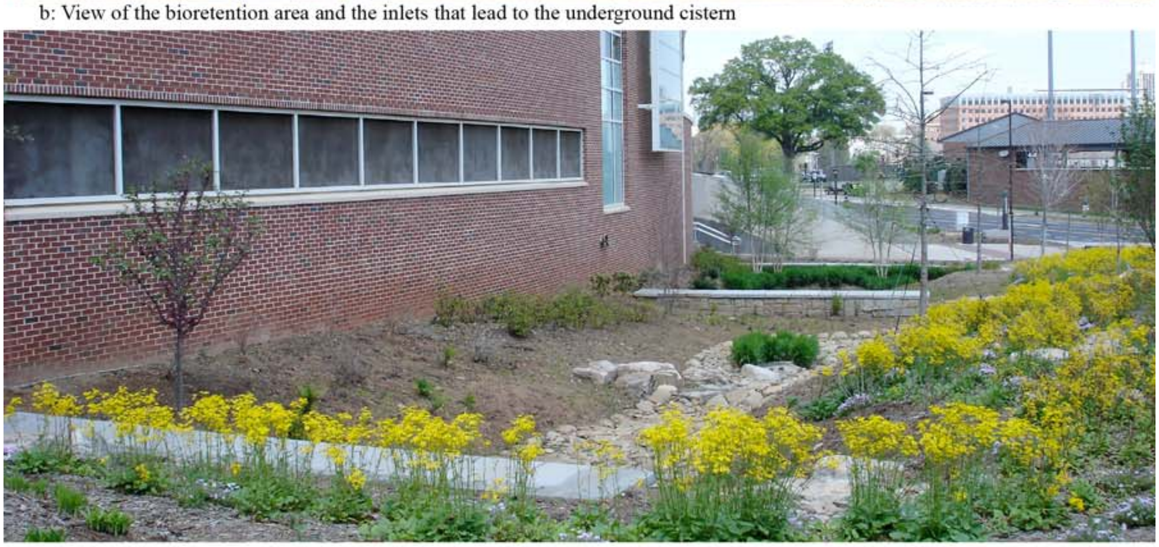
Portland Green Streets Program; Portland, OR

The Green Streets Program in Portland, Oregon takes an innovative approach to handling stormwater originating on streets. This program aims to treat street runoff by channeling it into specially designed bioretention planting strips that also allow the water to infiltrate. There are two types of implemented green streets. Figure 3.8e&f shows the curb extension bioretention type for smaller streets, while Figures 3.8a-d show the continuous planning strip type. Water flowing off these modified streets enters specially designed planting strips lower than the street level. This detail is shown for continuous streets in Figure 3.8c. The entry for the cub extension type is less complicated, and can be seen in the bottom of Figure 3.8f. Figure 3.8b shows the continuous planter during dry periods with its double grates: one that allows entry into the planter and one that allows overflow to pass back into the street. If during a rain event the planter fills beyond

[40] Stell, Andres. *Klaus Building*. Email from architecture firm employee to the author. 4/25/2008.
[41] Ibid.

a: Front view of the Klaus Building, the bioretention area is on either side of the staircase in the center

b: View of the bioretention area and the inlets that lead to the underground cistern



c: Side view of the bioretention area, showing the relatively new vegetation

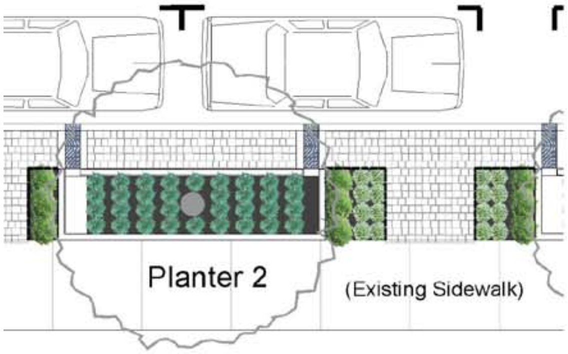
Figure 3.7: Georgia Tech's Klaus Building and corresponding bioretention area

capacity it passes out the other grate, moving further down the street. Figure 3.8d shows the continuous planter type during a rainstorm. Storm overflow for the extended curb retention area, works analogously.

The Portland Green Street program absorbs, detains, and treats stormwater originating on streets. Bioretention areas like these use principles of harvesting, detention, and, in this case, infiltration. The green streets have the same caveats as any infiltration system, but largely avoid problems with contamination by placing the green street renovations on smaller streets. If pollution were a concern, the infiltration function could be eliminated. This step would reduce the overall balance and effectiveness, but would still aid in treating and detaining stormwater. Aside from the pollution complication the Portland program shows great promise as a way to reconcile urban locations with smarter stormwater management. It is particularly useful because it does not require the large continuous tracts of green space, which are currently scarce in big-box developments. The Green Streets program serves as both an inspiration and a practical example for the management of street runoff in BUMDs.

Stormwater Example Conclusions

The existing examples and tactical approaches show that alternatives are both possible and feasible. The tactics include several methods for dealing with stormwater that address BUMD-neglected principles of infiltration, harvesting, and treatment. Each of these tactics can potentially be integrated without disrupting the typical BUMD program. The six examples show real world implementations of stormwater tactics often involved in a more holistic site strategy, in contexts ranging from park space to completely urban environments. These tactics and strategies have the potential for integration with BUMD site design. The next chapter will explore the use of some of the tactics and strategies integrated into the study site.

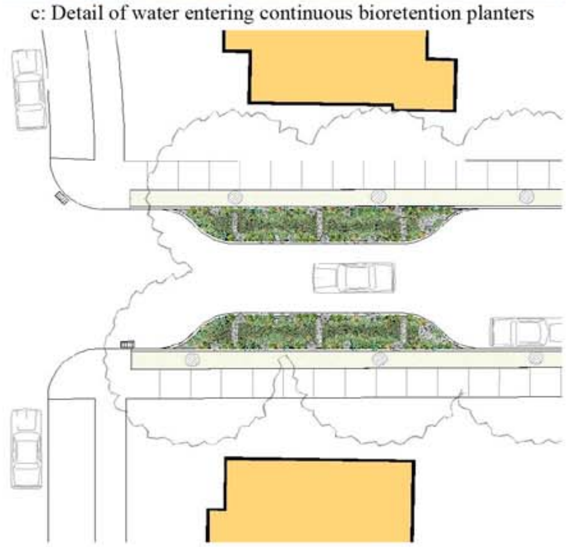


a: Plan diagram of continuous planter

b: View along 12th street bioretention planters

c: Detail of water entering continuous bioretention planters

d: Detail of water in continuous bioretention planters



f: Plan diagram of extended curb

g: Photo of extended curb bioretention area

Figure 3.8: Portland's Green Streets Program

CHAPTER 4

BUMD ALTERNATIVES

Overview

So far the effects of Big-box Urban Mixed-use Developments on stormwater have been covered as well as a site survey for a typical example of such a development. Most recently several tactics and strategies were examined for their applicability to big-box developments. In this chapter those strategies and tactics will be applied to the study site with the intent to integrate alternative stormwater strategies into the design.

Process

Existing BUMDs rely too heavily on conveyance and detention to manage stormwater, which causes the site to appear devoid of life and does not solve the root causes of stormwater issues. To counteract this imbalance, the alternative stormwater strategies to be tested are the stormwater management principles that are seldom used by BUMDs: infiltration and harvesting. One scenario will be explored for each principle in the context of managing a 25-year storm; in each case pushing the limits of the principle to expose the positives and negatives. The amount of program is constant between each scenario to make a fair comparison; only its configuration changes. Comparing the designed alternatives is the beginning of an exploration of how balanced stormwater management can integrate into BUMDs.

Infiltration

Strategy Overview

The ERD redesign aims to maximize the amount of water infiltrated on site to test the limits of this approach. Two basic principles are needed to do this. First, maximize permeable surfaces to infiltrate as much water as possible. Second, capture and infiltrate

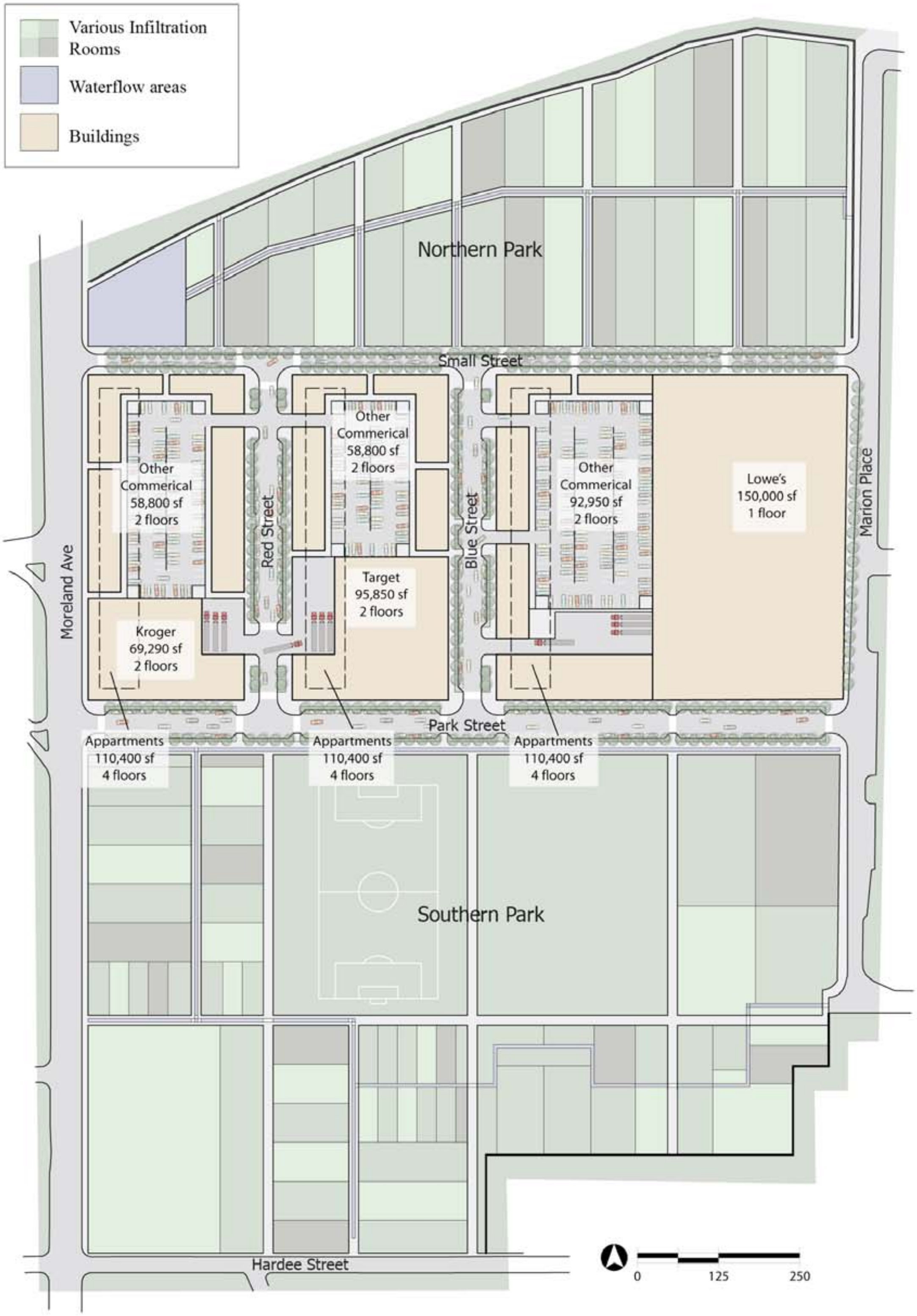


Figure 4.1: Infiltration Scheme Illustrative Plan

runoff from impervious surfaces as well. To meet these challenges in a Big-box Urban Mixed-Use Development requires a coherent site design strategy. The first strategic move was to minimize building footprints, by building multi-story structures that could accommodate boutiques, big-box retailers, and adequate amounts of parking without impeding their main function. Incorporating big-box retailers into multi-story formats eliminated the large roof coverage and also eliminated parking as a stormwater concern. The second move was to minimize the impact of streets, the only remaining impermeable surface, without compromising their ability to serve their public space and transportation roles. The last move was to use the space saved from the first two steps to create landscaped areas that would infiltrate the water both from on and off-site and simultaneously create a usable amenity. The site plan (Figure 4.1) demonstrates the results of these moves and the configuration of programs.

Components of the Infiltration Design

The exploration of the design strategies on site yielded a series of individual components that would assist in both stormwater management and in making more interesting spaces. The individual components will be described below to explain their placement and functioning. After each of the components is examined, the overall site stormwater strategy will be discussed.

Infiltration Rooms

The first concern in any infiltration scheme is where the infiltration will occur. Though the basic infiltration basin is unexciting, projects like Victoria Park demonstrate that these areas can be appealing as well as useful. To maximize the use of infiltration areas the infiltration rate must be known. Rates of infiltration were found for the HSG type 'B' soils found at the ERD site to be around 1.43 feet per day[42]. To infiltrate in a reasonable time frame of 24 hours and to maximize the use of any infiltration basin, any such basin would require a lip 1.43 feet above the bottom of the basin. This inspired the idea of an infiltration 'room.' Like a room in a house, an infiltration room allows for different activities to occur in adjacent areas. Each room would be separated by a small wall that would allow water over the 1.43' level to flow out of the basin to be conveyed elsewhere. Any water remaining would infiltrate within 24 hours. Each of these rooms would have a different use that would allow water to infiltrate unhindered. This could allow a wide variety of interesting programs over the span of the site. An example may be a Japanese rock garden or horticultural room; a rendering illustrating this concept is seen in Figure 4.2.

Figure 4.2: Rendering of Infiltration Room and Waterway Concept

Ramps like the one shown in Figure 4.3 provide access to the rooms. An infiltration basin

---

[42] Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.

that is not capturing run-off from elsewhere is underutilized; it can be used as a 'sink' for stormwater. The problem is transporting stormwater to the infiltration basins. This problem inspired the second component: the stormwater waterway.

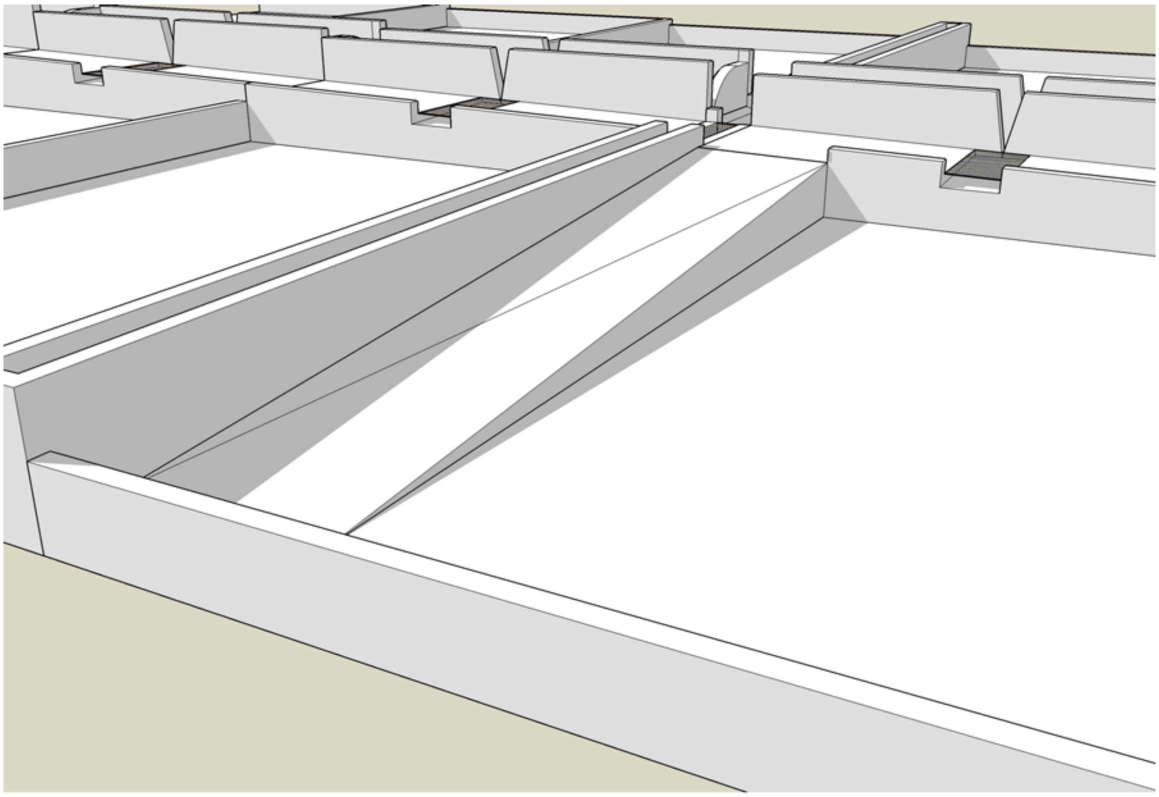


Figure 4.3: Illustration of access to infiltration rooms

Modular Waterway

One of the chief concerns is how to distribute water from impermeable surfaces to permeable ones where you might infiltrate, such as an infiltration basin. Ensuring that the water distribution is fairly even over a large site with varied topography requires some transport. The answer to this problem is the modular waterway shown in Figure 4.4. It is designed to be a modular structure that can easily be repeated over the entire site. It functions like a series of buckets; it fills to a certain small level before passing the water on to the downstream module (see Figure 4.5). At the same time, a small notch allows for

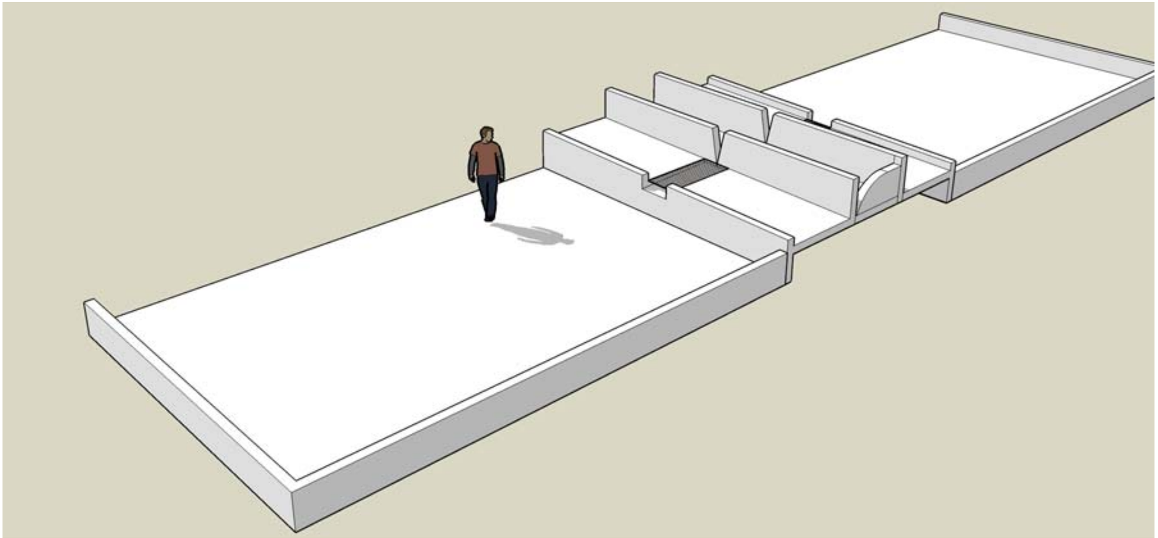


Figure 4.4: Illustration of waterway module with pathways and infiltration rooms attached

a portion of that water to trickle out the sides to flanking infiltration basins. The bottom of the waterway can either be smooth, or allow for some permeability to create more of an enhanced swale; it depends on its location in the site. The waterway module features an arc-shaped notch on the front to allow for water flowing to the subsequent waterway modules to increase as the level of water increases, as indicated in Figure 4.5. Multi-purpose paths flank the sides of the waterway module. These paths can accommodate cycling, running, as well as wheelchair access. The combination of the waterway with the paths creates a network of both stormwater and pedestrian circulation across the park spaces on the site.

The waterway modules connect to the infiltration basins though a small grate-covered channel in the path module, shown in Figure 4.5. The waterway notch that feeds the channel between the two is v-shaped to allow more flow as the water level rises. This provides a more even water distribution so the upstream modules are not flooded while those farther below are still dry. As a flood prevention measure, the infiltration basins are designed to spill into the next basin downstream if they fill past their infiltration limit. This overflow process continues down to the lowest basin, near the southwest corner of

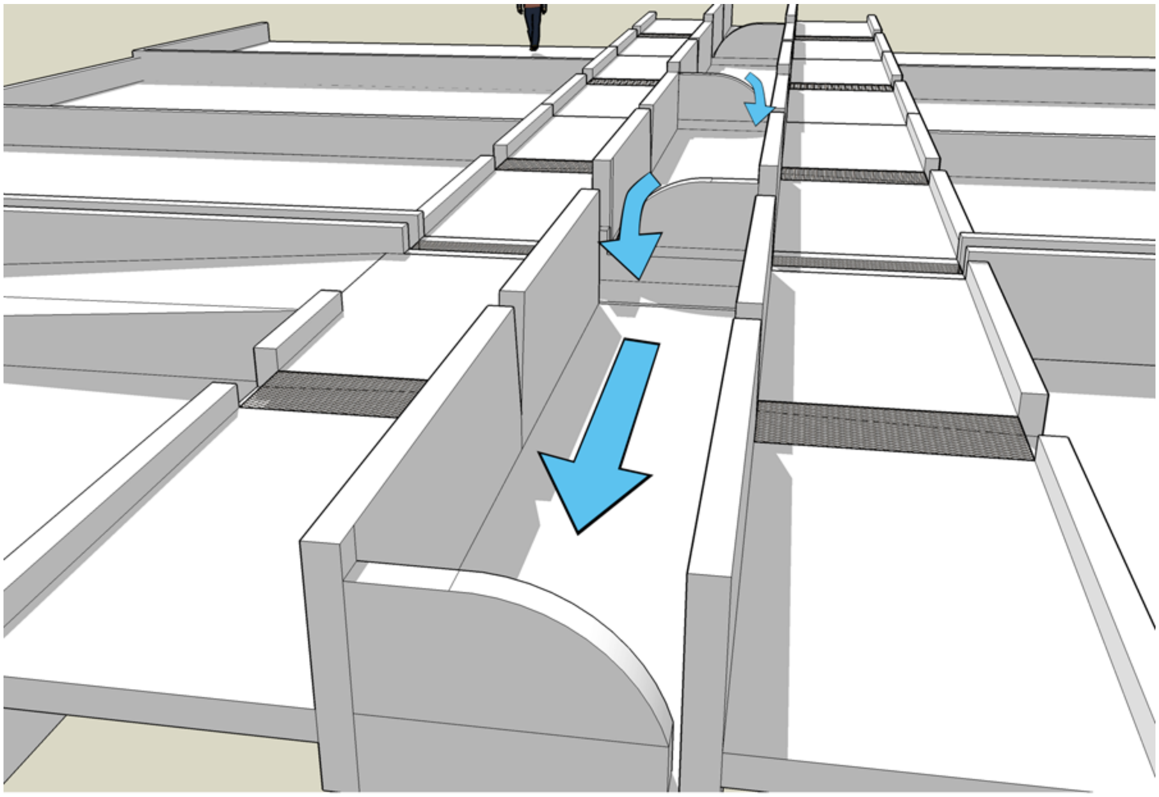


Figure 4.5: Detail of waterway module, showing water flow path from module to module

the site, which spills over into the existing storm drain. In this fashion, infiltration can be maximized while still allowing for conveyance if an exceedingly large rainfall occurs.

Bioretention Planters

One of the concerns of all infiltration schemes is pollution and sediment. In order to address this in the infiltration scenario a series of bioretention areas helps to filter and treat water before passing it on to the waterway system. The sources of pollution in this scenario are the streets. The water flowing off of them is designed to flow towards one of the park edges. Taking a cue from the Portland Green Streets Program, street planters are implemented as bioretention basins between the park and the street. A diagram of this concept can be seen in Figure 4.6. Along the edge of the parks the streets are graded to drain to the park side as seen in Figure 4.6. Upslope, the sidewalk and roof drainage are channeled into a bioretention planter. Planted with a mix of hardy trees and perennial

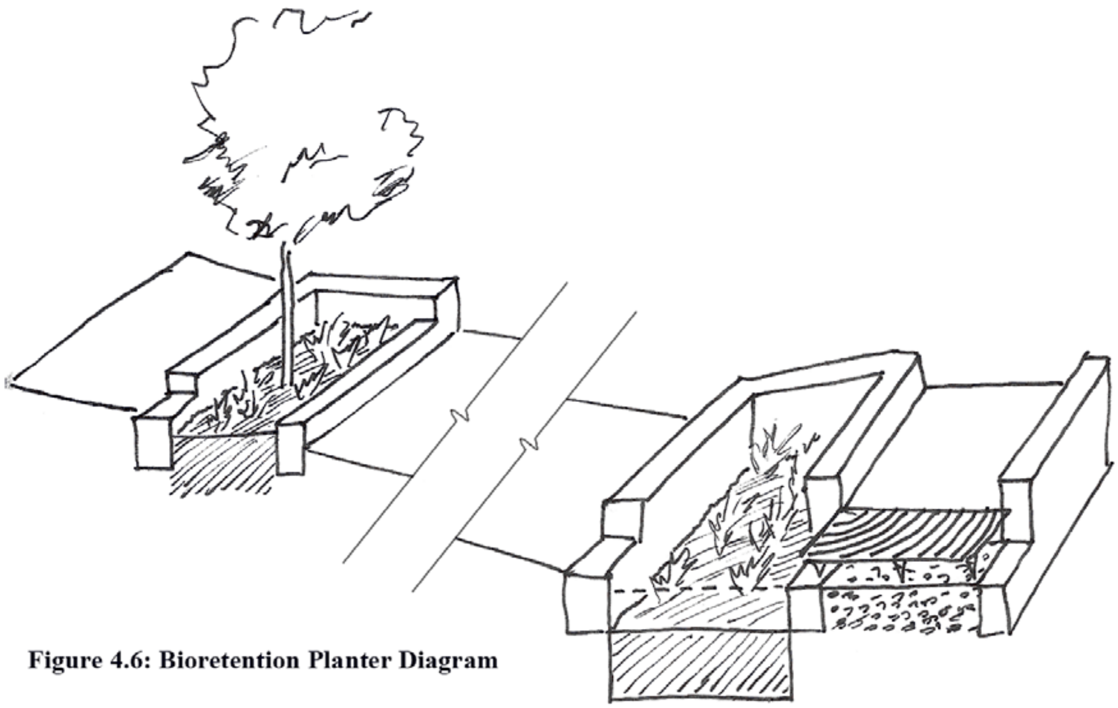


Figure 4.6: Bioretention Planter Diagram

shrubs, the planter detains, infiltrates, and treats that stormwater. This upslope planter fills up to the maximum level of 24-hour infiltration before spilling onto the roadway. Since the roadway is sloped towards the park side, the water flows over to the penetration in the curb there and into the downslope bioretention planter. Because of the concern for pollution from roadways, the downslope planter does not infiltrate, it simply detains the water for a period time, treating it, catching sediments, and reducing the volume through the transpiration of the plants there. Infiltration is prevented through the installation of an impermeable layer a few feet below the soil. If the water overflows the maximum level in the downslope basin it flows under a grate in the sidewalk towards the waterway system. As an extra precaution against groundwater contamination the first waterway module is designed especially to slow water and further treat it with more vegetation. In the north-south streets the scheme just described does not work, as there is no park space or waterway on which to offload the stormwater. The result is a configuration similar to the continuous Portland Green Street planter, shown in Figure 4.7. Here the water flows from upslope through a cub cut into the bioretention basin. Once the basin is full it flows out the downslope curb cut further down the street. An additional detail, also visible in

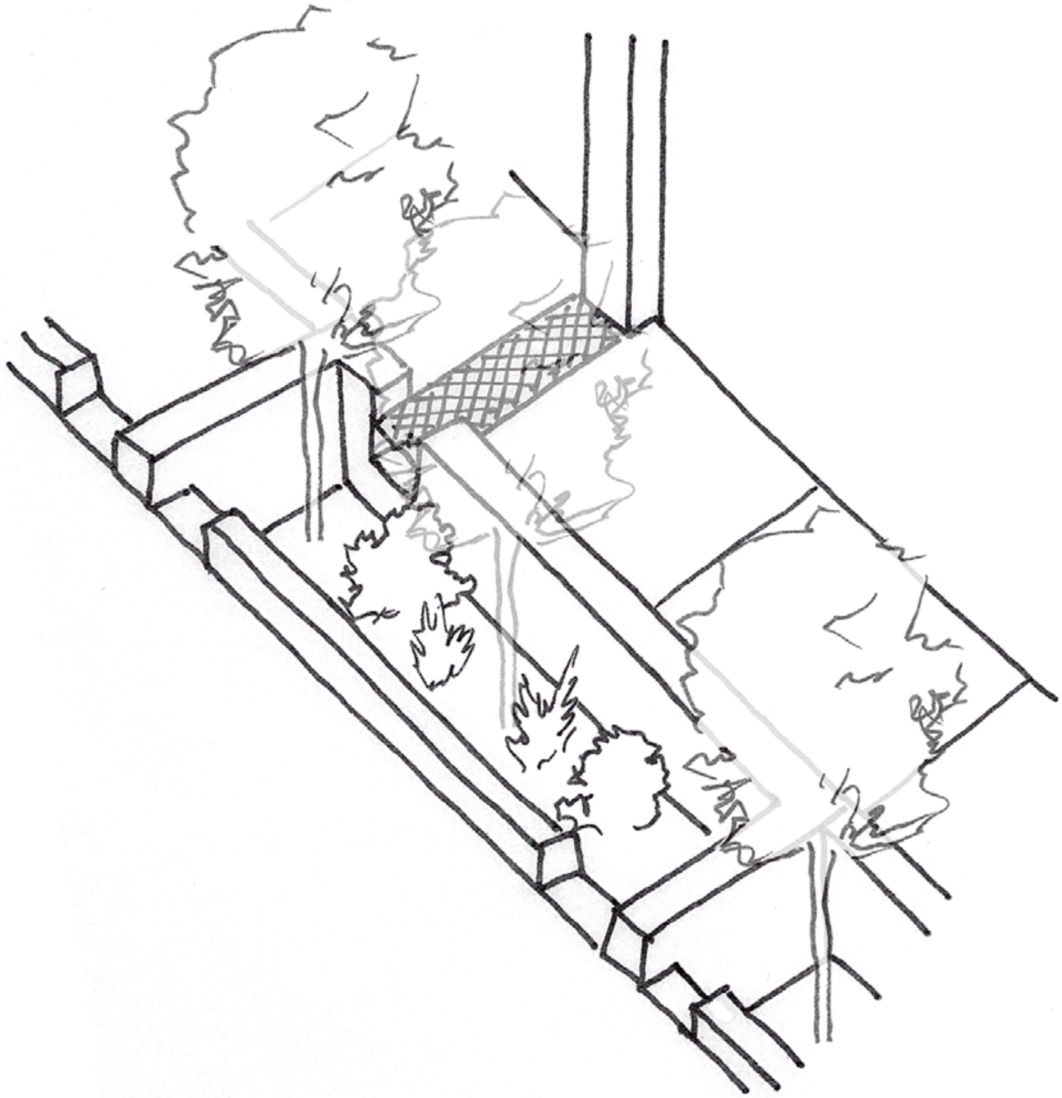


Figure 4.7: Bioretention Planter Diagram for North-South Streets

Figure 4.7, is that roof drainage is diverted into the basins through a grate-covered channel in the sidewalk. Since contamination is still an issue an impermeable layer is installed as in the bioretention basin adjacent to the park.

Lean Streets

Yet another component to make the infiltration design scheme work is the slimming of streets. This is a balancing act since there are two contradictory aims. One is keep a steady flow of traffic while making a pleasant urban street. The second is the

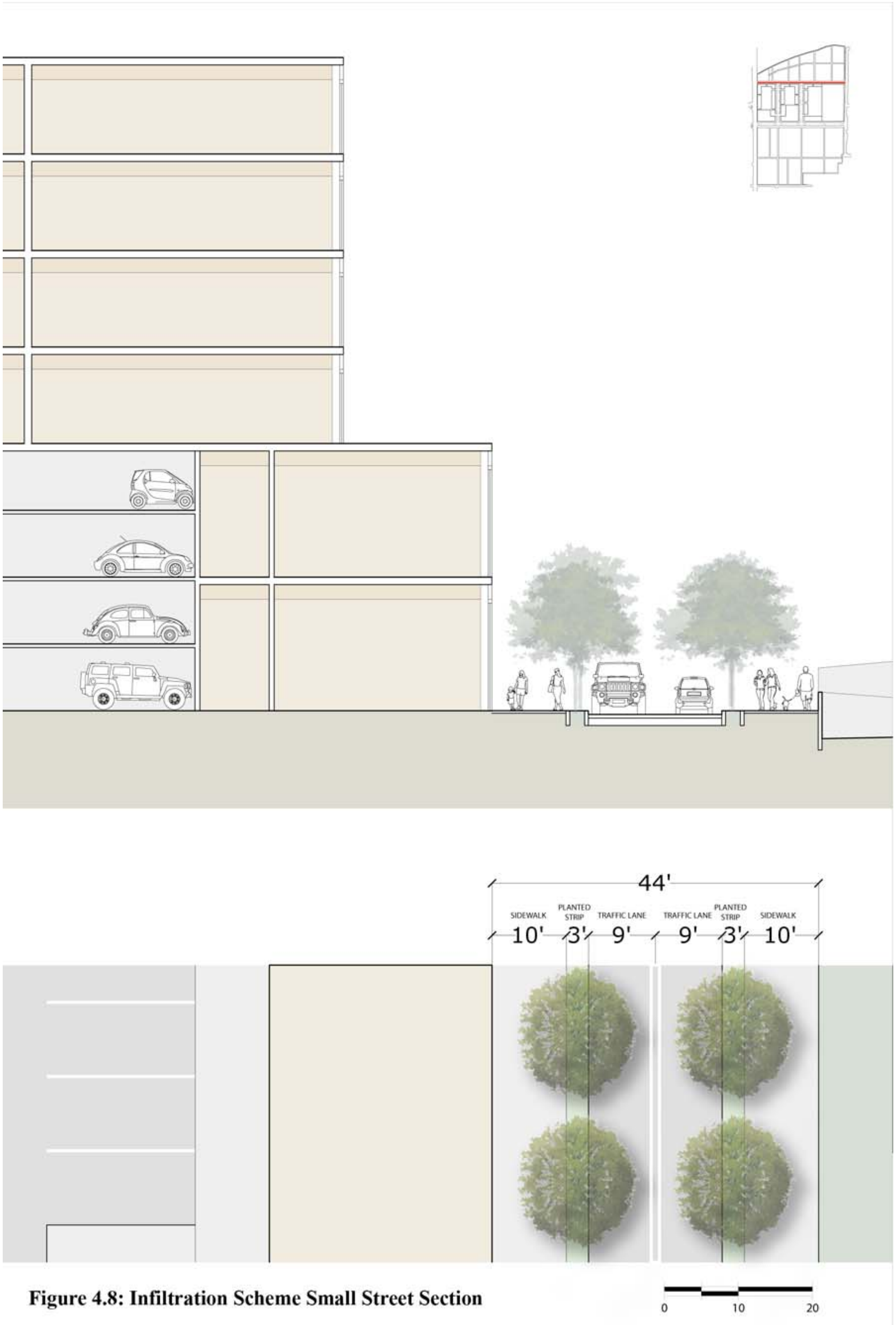


Figure 4.8: Infiltration Scheme Small Street Section

desire to minimize the amount of stormwater generated. The balance between these opposites is seen in the street sections. There are two main types of streets: the smaller street to the north (see in Figure 4.8) and the larger one to the south (in Figure 4.9). There is also a street section similar to the larger street shown in Figure 4.10, which differs because it occurs on north-south streets. The Park Street is larger because this is the end of the development on which the big-box retailers front and where their delivery trucks enter. It includes on-street parking on both sides for the Southern park as well as for the short-term use by big-box shoppers. To encourage a more varied and lively street a five-foot bike lane was added in each direction. In every section the sidewalk is kept to a comfortable ten feet but no larger. Similarly traffic lanes are kept to nine feet to allow for relatively free flow but small enough to slow traffic and prevent too much stormwater generation. The condition of North-South streets is demonstrated in Figure 4.10. It is virtually identical to the large street section, but the area utilizes the second type of bioretention area designed for this condition.

The small street that runs along the northern park is intended as a low volume neighborhood street. To accomplish this the on-street parking and bike lanes were eliminated, leaving only two traffic lanes, narrowed planting strips, and sidewalks; it is drawn in Figure 4.8.

Multi-story buildings

The last but crucial component of the stormwater strategy was the multi-story buildings. Big-box developers are traditionally reluctant to build upwards, but increasingly there are examples of retailers who are willing to do this. Figure 4.11 shows some of these retailers. Target has done several multi-story projects including a 3-story renovation in Glendale, CA pictured in Figures 4.11a&b. Kroger, has done a few 2-story projects including one at Brookwood Plaza in Atlanta. However, the retail floor here is limited to the first floor. The Publix in Miami Beach, FL shown in Figures 4.11c&d is

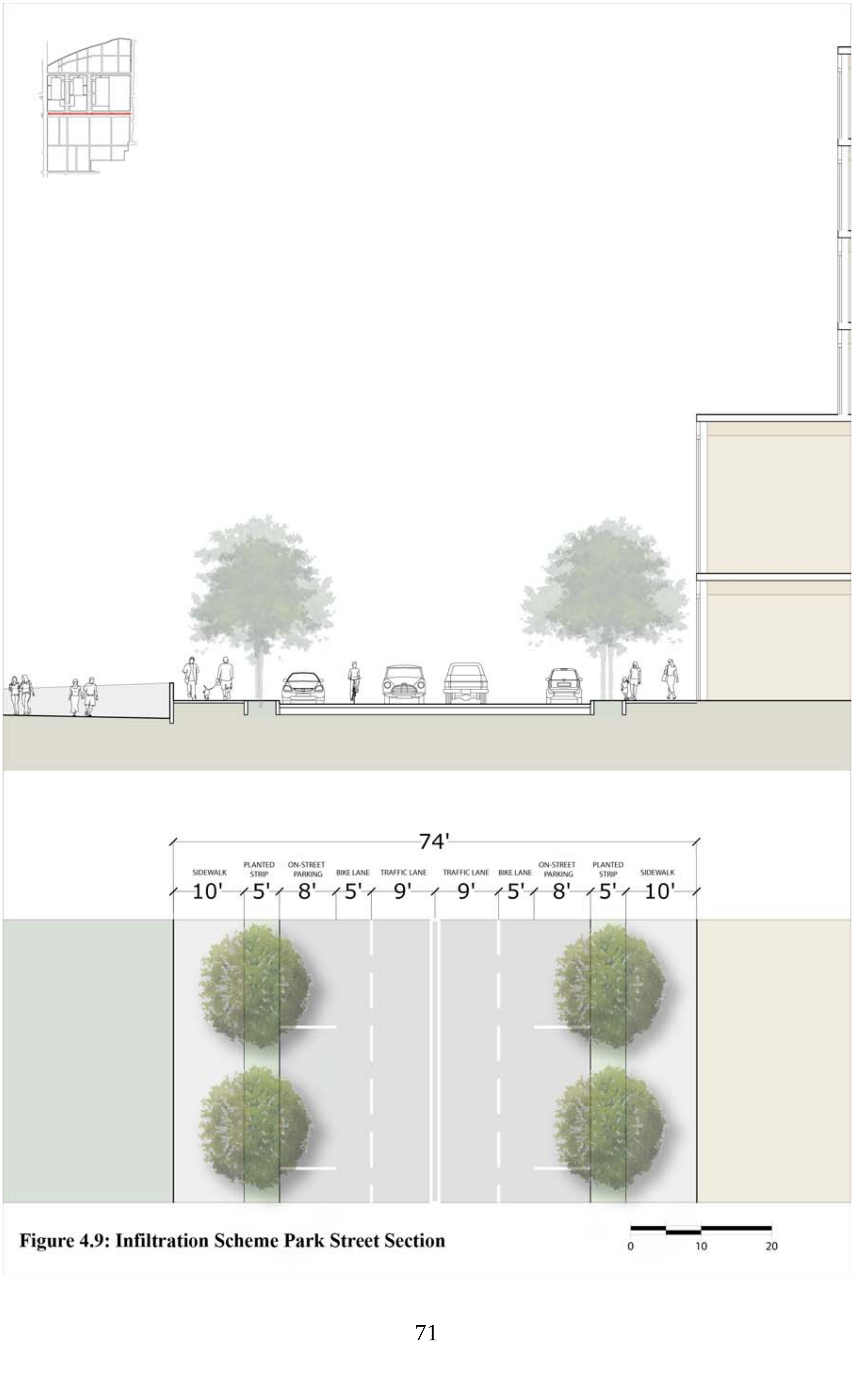


Figure 4.9: Infiltration Scheme Park Street Section

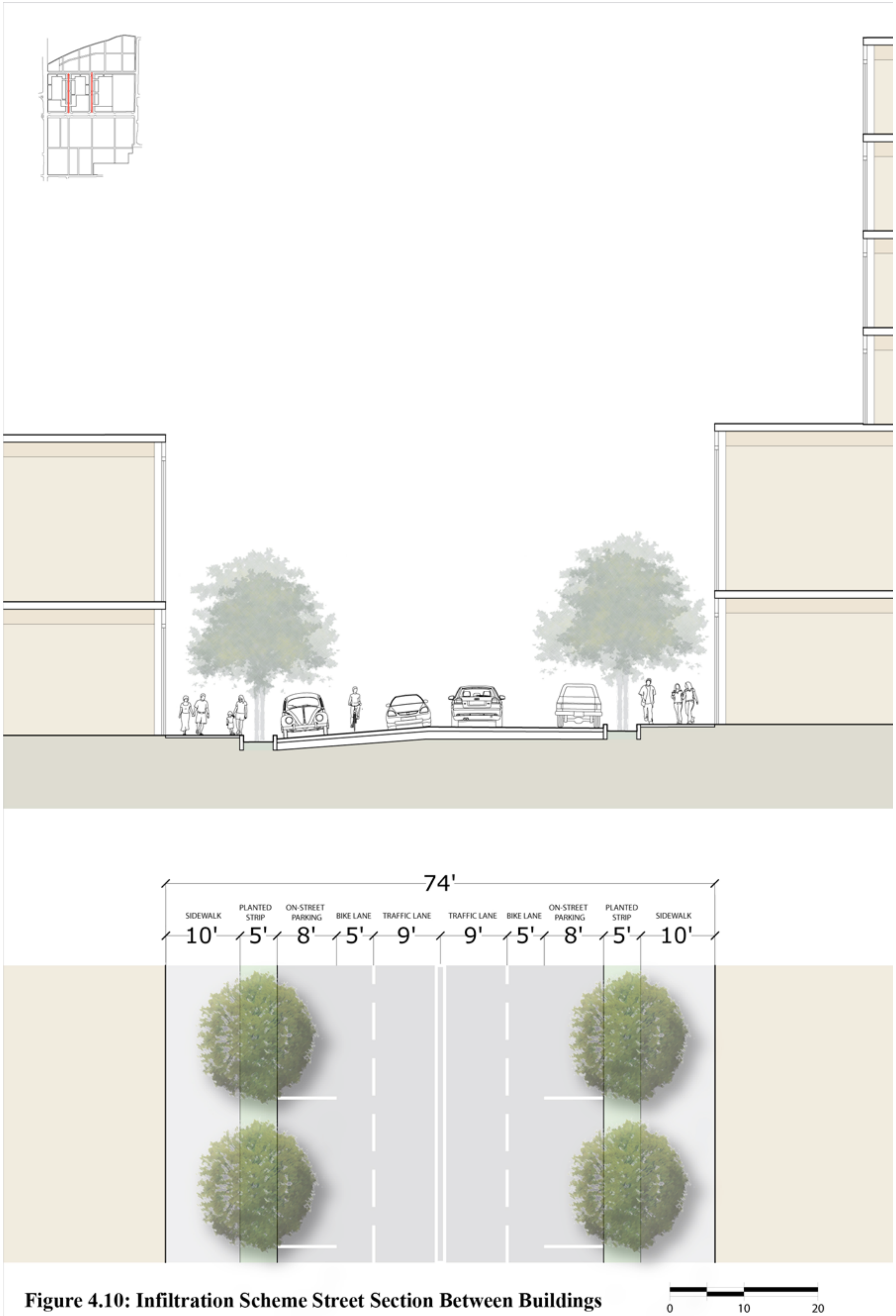


Figure 4.10: Infiltration Scheme Street Section Between Buildings

more interesting. Not only does the store have a shopping cart escalator, seen in Figure 4.11d, but it also has parking situated on the roof. However, the largest big-box retailer, Lowe's, does not accommodate multi-story development. This is likely due to the contractor focus of the store. Lumberyards and garden facilities are difficult to incorporate into a multi-story format. Several multi-story Home Depot Stores have been built, such as the one in Manhattan pictured in Figures 4.11e&f. Unfortunately, these stores focus on consumer-grade products and small do-it-yourself solutions, rather than catering to contractors. To have an honest comparison, the Lowes must remain single story in the infiltration scenario.

The typical configuration of the multi-story buildings is illustrated in Figure 4.12. There is a 2-story double-height space for the largest big-box retailers, like Target and Kroger, shown in grey in the foreground. The block of blue in the middle is the 4-level parking deck. The entrance to the loading dock can be seen as an opening on the right side in the front. This dock serves all the retailers in the entire building with space for several trucks. The rest of the 2-story commercial space is wrapped around the entire parking deck with breaks for pedestrian and vehicular access to the interior. This results in plenty of space for other boutiques. Last, a 4-story bar of residential, shown in yellow here sits on the western edge of the building. This bar repeated on each of the 3 buildings results in slightly more housing than at ERD. Sections that demonstrate the relationships between the different pieces can be seen in Figure 4.13.

Fitting it Together

Though each one of the components is an essential piece to the infiltration scheme, without an overall strategy they would be far less useful. It is the integration of the individual pieces that creates a better development. The strategy diagram is shown in Figure 4.14, which shows the individual pieces as they relate to one another and the stormwater processes that are involved with each step. To summarize: if rain lands on

a: Exterior of 3-story renovated Glendale Target

b: Interior of Glendale Target

c: Exterior of 2-story Miami Beach Publix

d: Interior of Miami Beach Publix with shopping cart escalator

e: Exterior of 2-story Manhattan Home Depot

f: Interior of Manhattan Home Depot

Figure 4.11: Pictures of Multi-story Big Box Retailers

any of the exposed surfaces like the roof, street, or infiltration basin it ends up infiltrating into the designated basin unless it is larger than a 25-year storm, in which case, the water would spill out the storm drain to protect the development from flooding. The off-site drainage is an important piece, because it represents almost half of the pre-development stream of stormwater. To understand the specifics of the water flow view the grading diagram (Figure 4.15), which shows the slopes and directions of the grading. This directly correlates to the flow of water; water always flows downhill and steeper slopes lead to faster flow. Essentially the bulk of the water flows south toward the Southern Park, while the northern portions of the site flow north to the Northern Park.

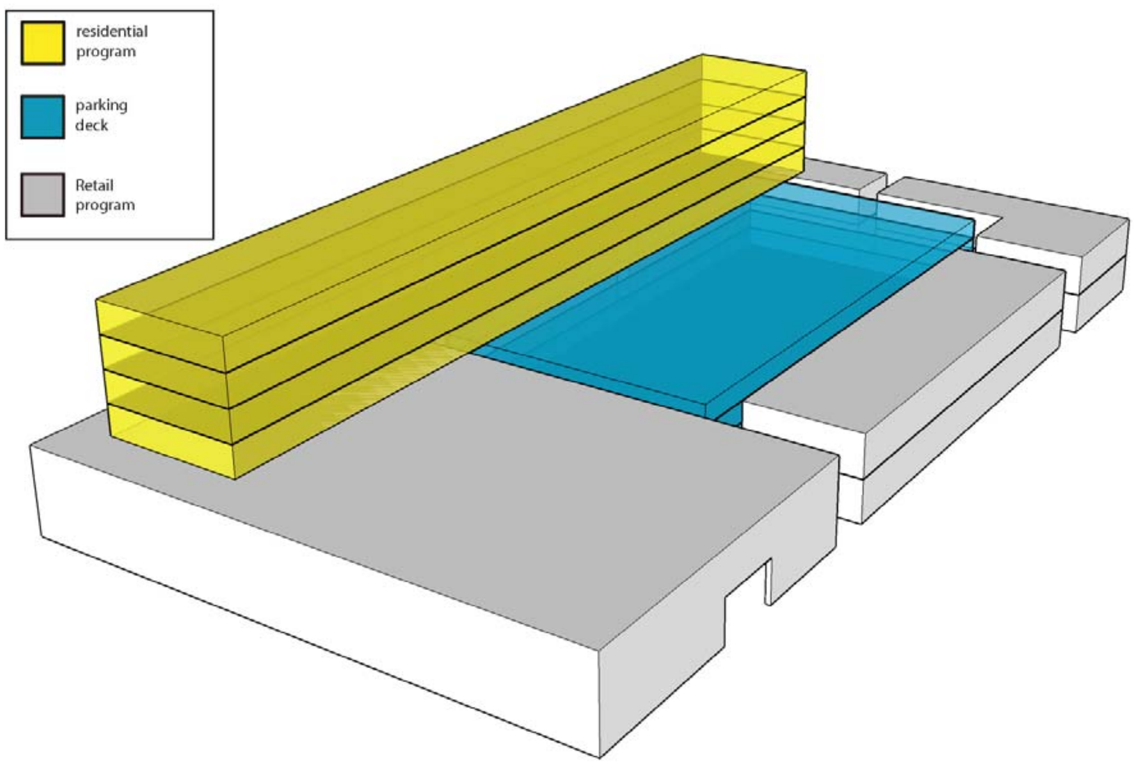
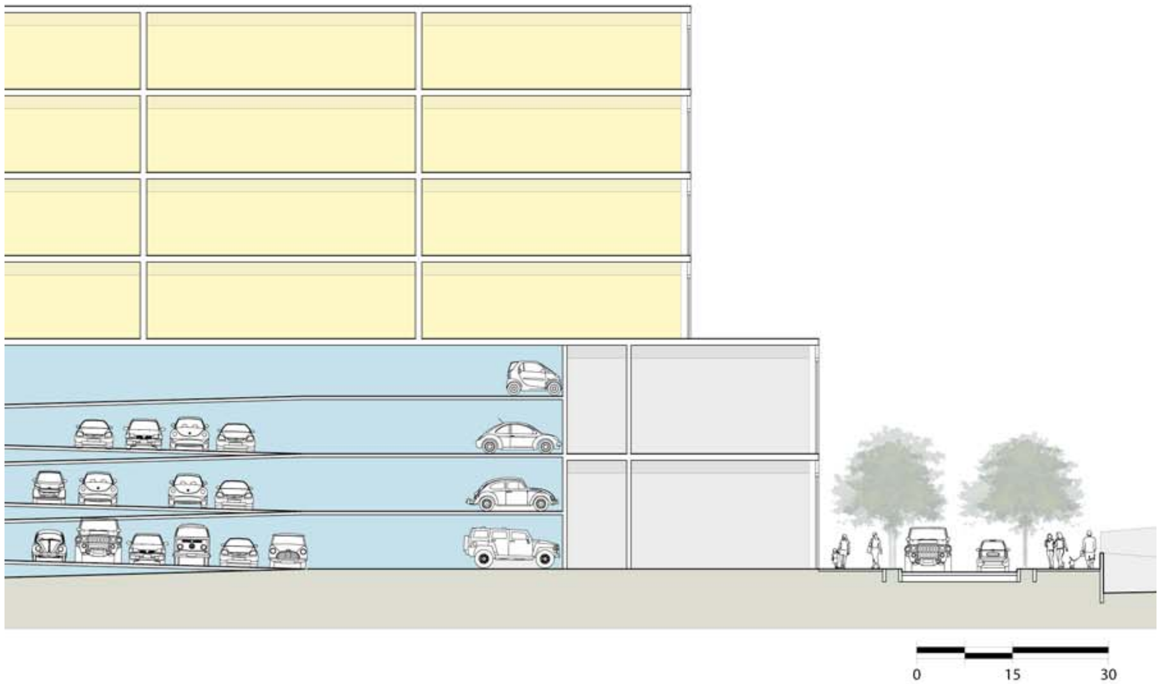


Figure 4.12: 3D Model of typical multi-story building for infiltration scenario

To address urban issues and relationship to the surrounding areas, the building heights and volumes were kept as low as possible, while still keeping the same amount of program. The relative size can be seen in the site sections (Figure 4.16). The neighbors are far less likely to object to medium-rise buildings if its construction allows more



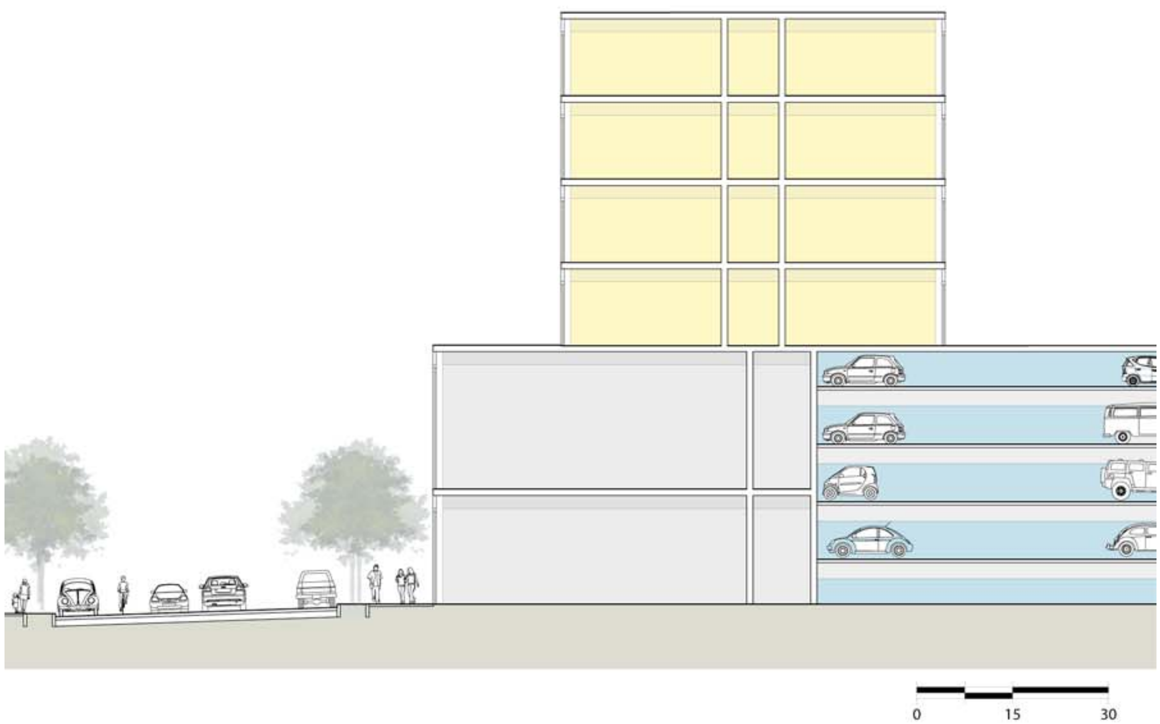


Figure 4.13: Infiltration Scheme Building Sections

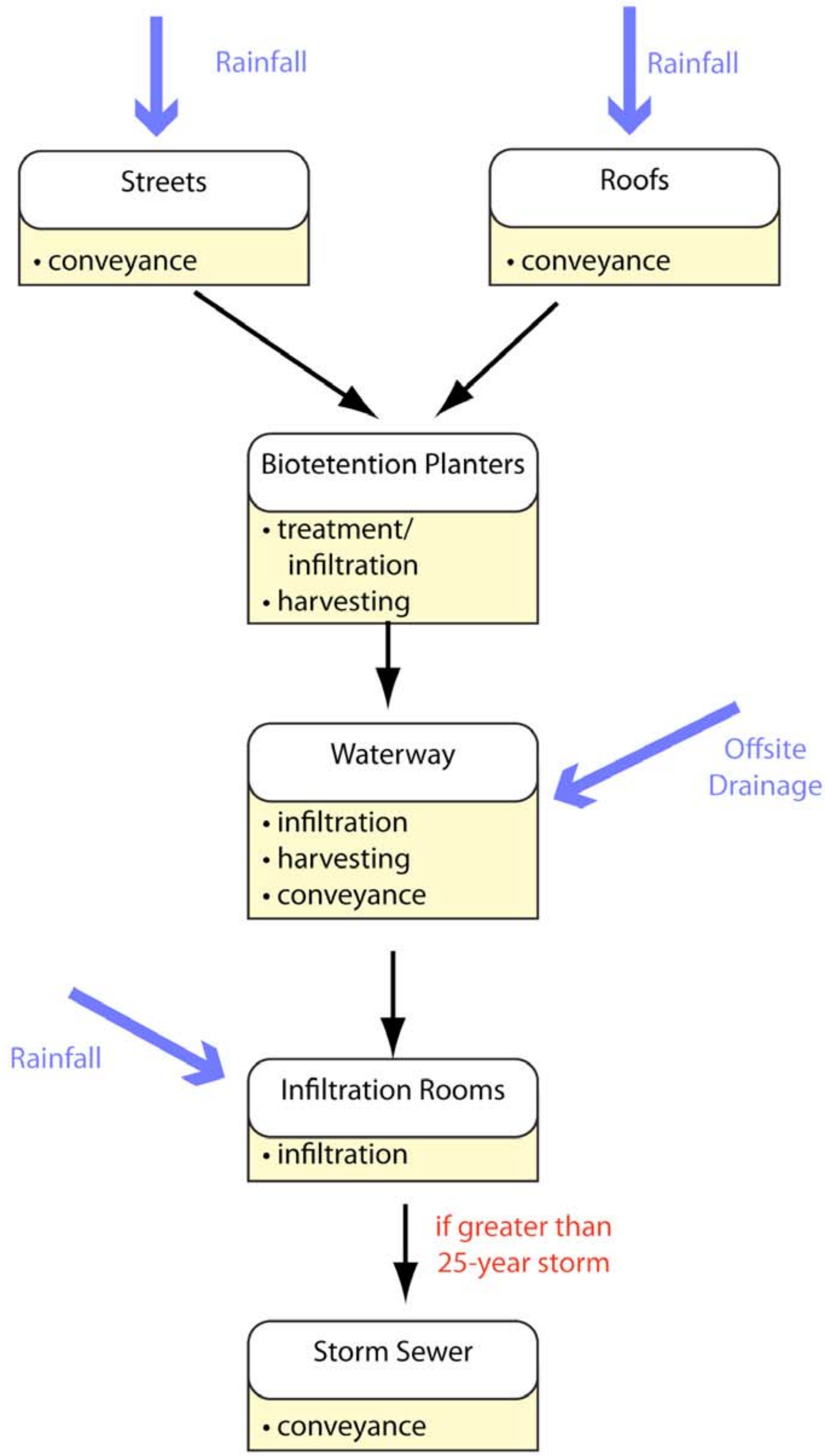


Figure 4.14: Infiltration Strategy Flowchart

greenspace. Connection with neighboring streets would be ideal in this scenario. However, because of the topographical constraints of the site, connecting the new streets with Seaboard Avenue was not possible without a fair amount of piping from one site to another. This seemed counter to the experiment. One remaining concern is the Lowe's side facing Marion Place. Though it is just one story, it is a long side exposure without any activity. Though it is not very elegant, the current solution is a screen of trees and shrubs to partially hide the development.

In summary the infiltration scenario shows promise for integrating stormwater techniques into a fairly urban space. The next chapter will test its stormwater effectiveness against the harvesting scenario as well as the pre-existing development and the ERD. However, the harvesting scenario must be described first to complete the picture of alternative stormwater strategies.

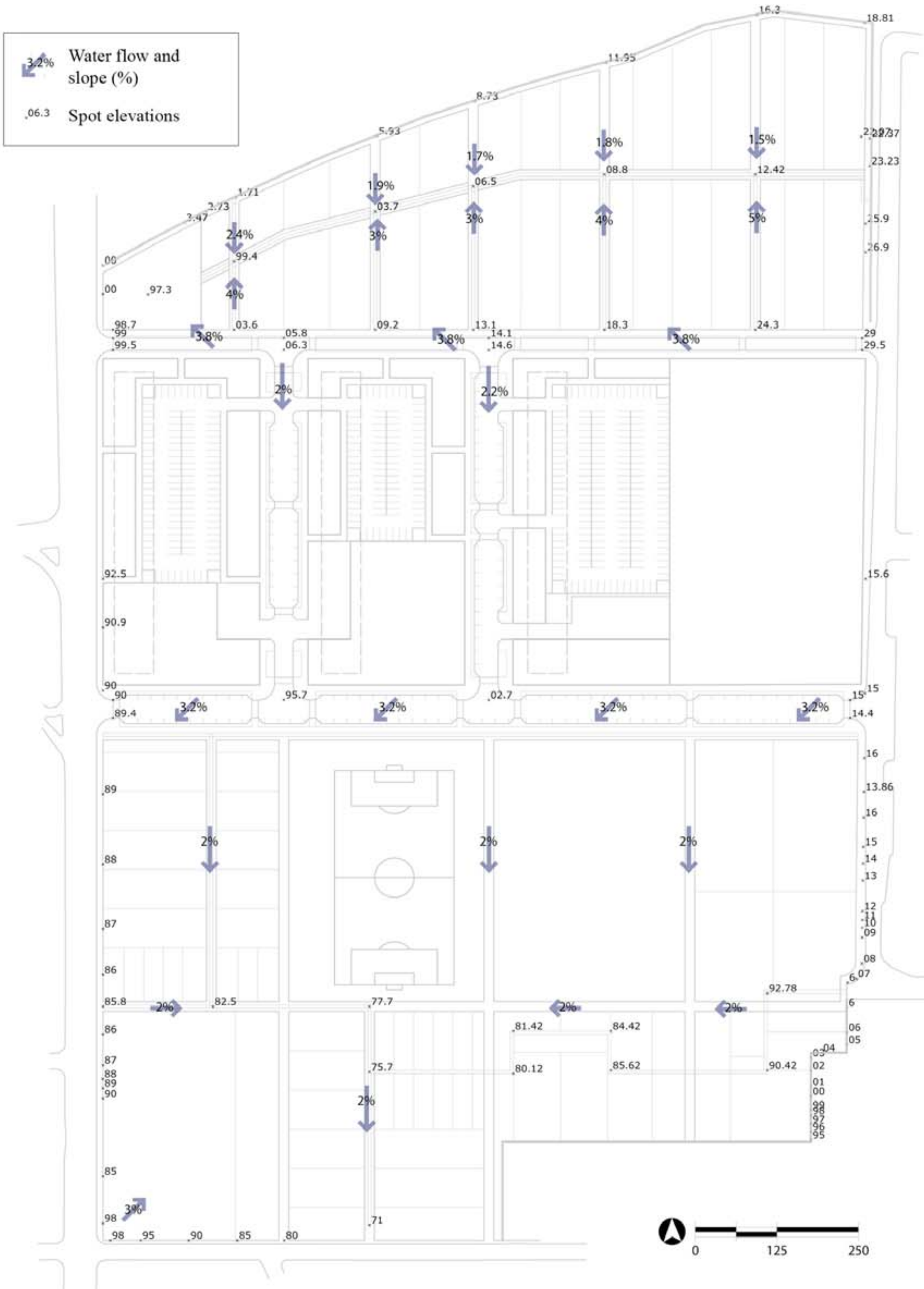
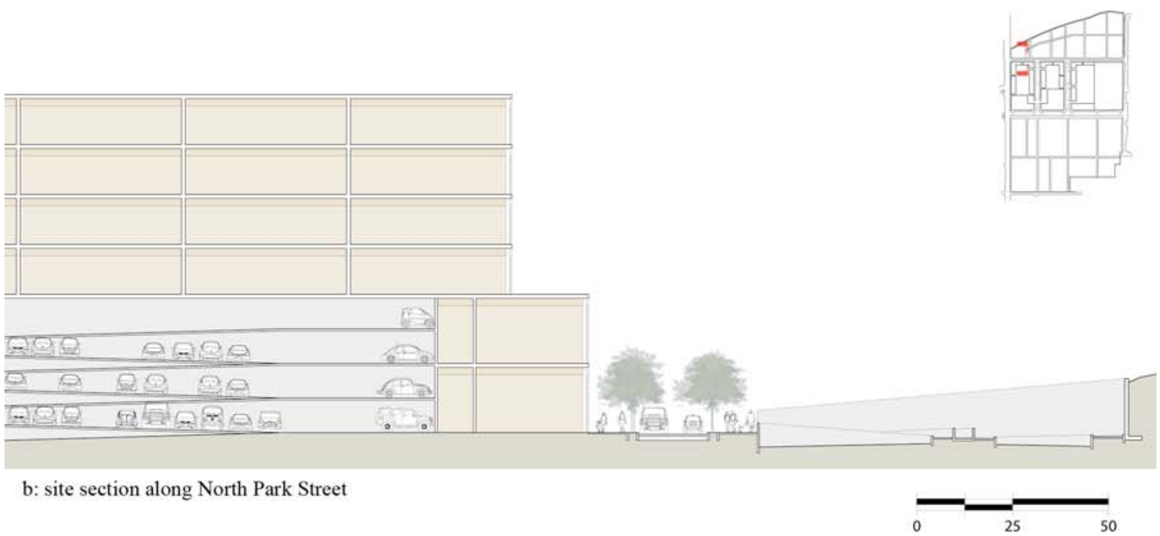
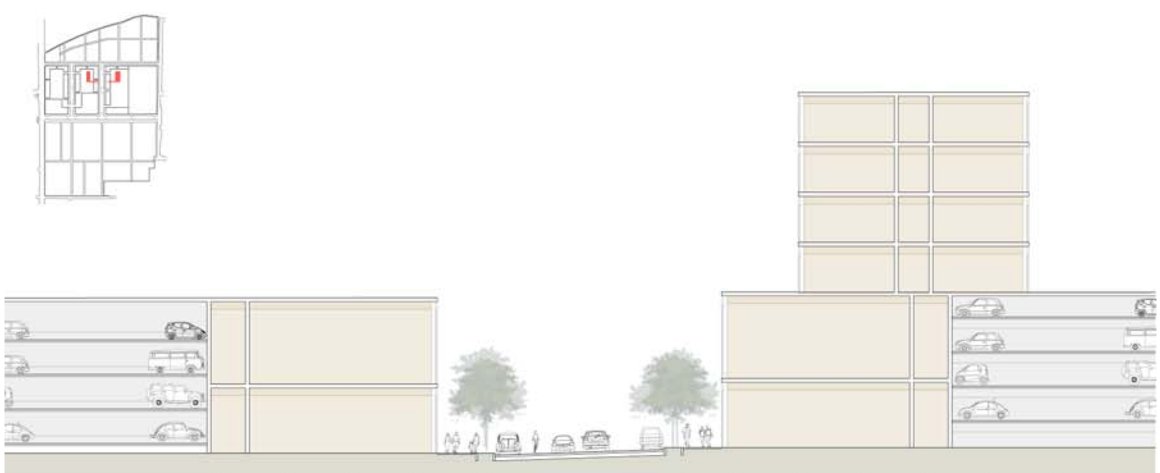


Figure 4.15: Infiltration Grading and Stormwater Flow Diagram

a: site section along Park Street



b: site section along North Park Street



c: site section through two buildings

Figure 4.16: Infiltration Scheme Site Sections

Harvesting

Harvesting Strategy Overview

There are two main guidelines to test the limits of the stormwater harvesting scenario. The first is to attempt storing all the storm run-off for the design storm. To ensure collected water is clean, the second guideline was to both avoid contamination and maximize the collection area to harvest rainfall directly. Applying these guidelines to the big-box urban developments resulted a simple site design strategy. The first move was to spread the existing program as thinly as possible and cover it all with vegetated roofs. This practice ensures that the maximum area is covered while also cleansing the water of impurities. It also had the effect of avoiding the contamination found on streets and lawns. The second move was to minimize conventional streets and parking. Both are sources of pollution that could contaminate the harvested water. Alternatively modify them to purify water. These moves applied to the Edgewood site can be seen in the site plan in Figure 4.17.

Components of the Harvesting Scheme

Like the infiltration scheme, the strategy is made up of several individual components, each which serves a specific function to make the whole thing work cohesively. Each of these components will be described and detailed below, to reach a more complete understanding of how the scenario works. After which follows a more detailed discussion of the site strategy and concerns.

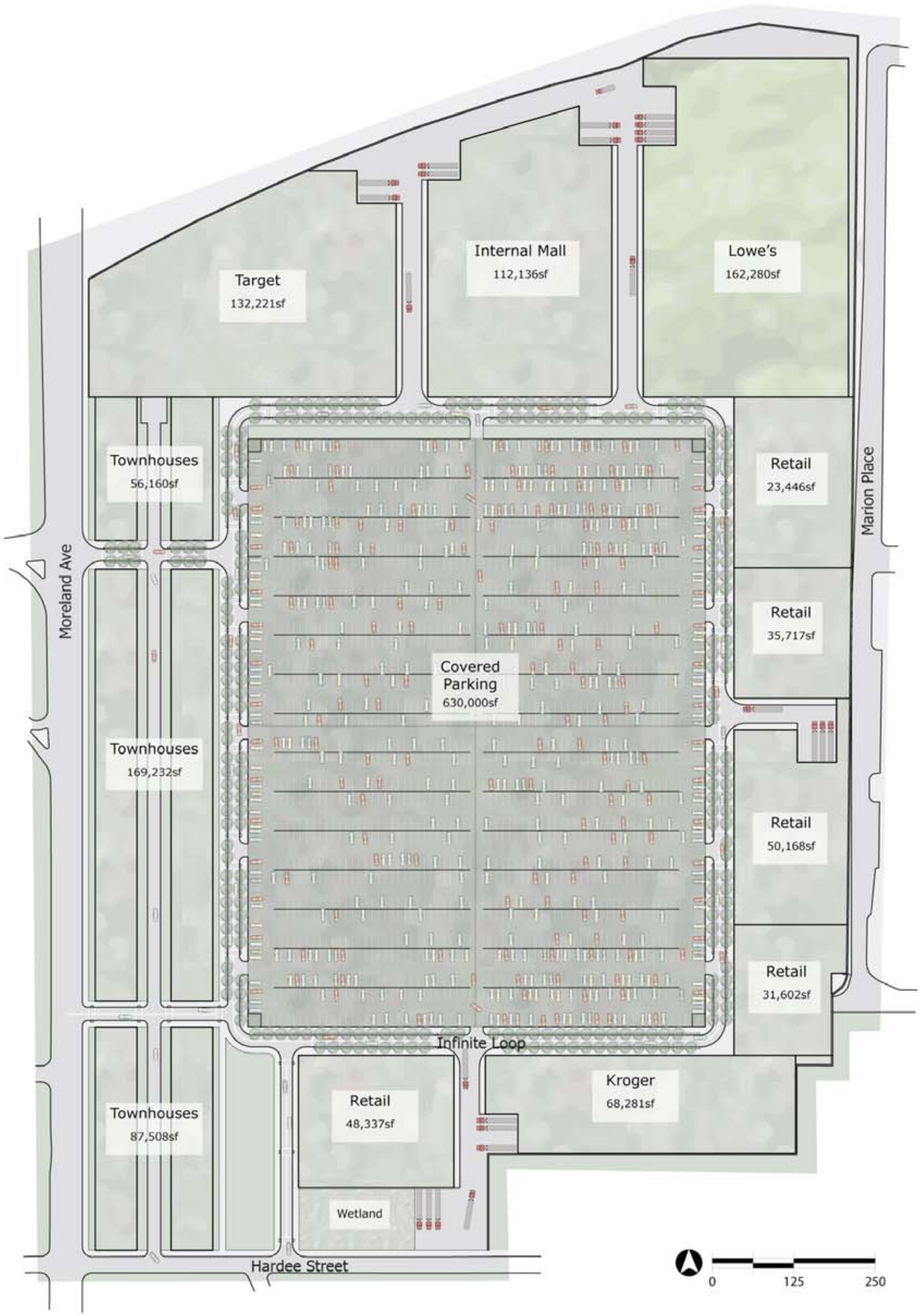


Figure 4.17: Harvesting Scheme Illustrative Plan

Water storage

In any water-harvesting scheme water storage represents a large part of the design. On this site a system of smaller aboveground cisterns would work better and be less costly than a single underground cistern, which would represent a significant cost. The aboveground cisterns have the advantage of modularity and changeability, while also allowing for gravity fed or gravity-assisted pumping. This allows the stormwater collection and storage to adapt as tenants change. The cisterns basically come in two varieties, the smaller version for home use and a larger version for commercial uses. A diagram showing the basic dimensions of the commercial water cistern is shown in Figure 4.18.

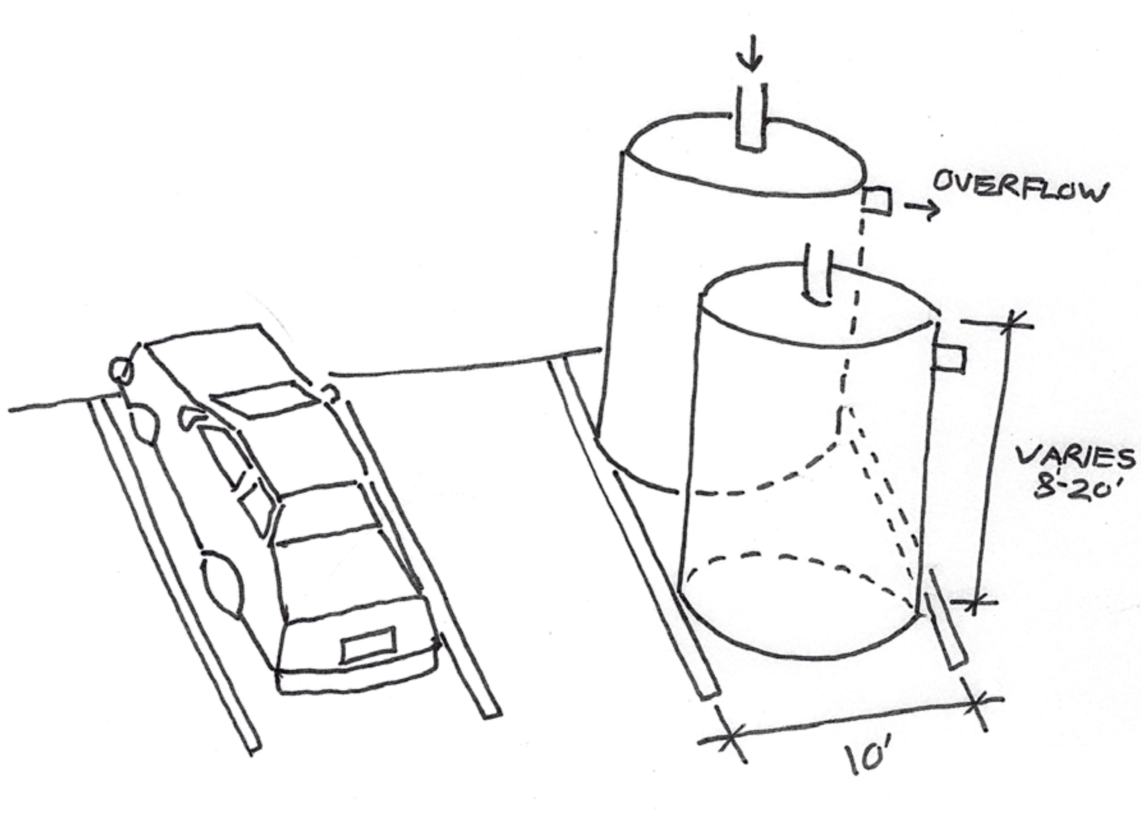
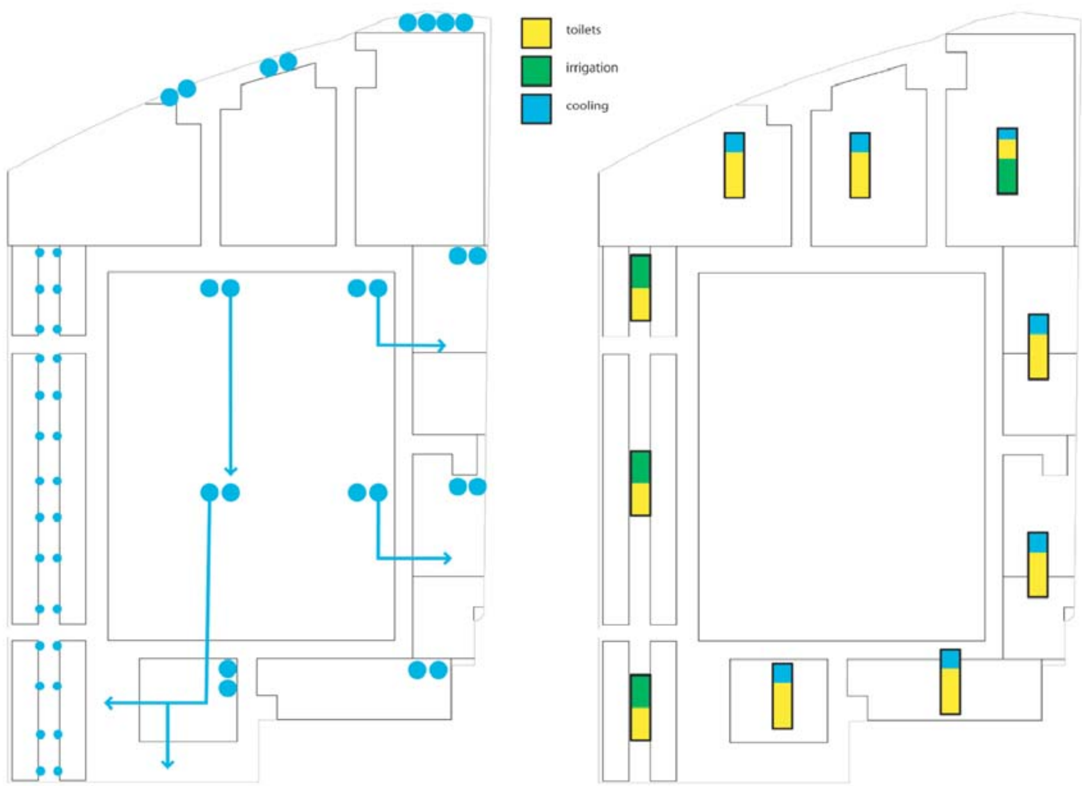


Figure 4.18: Sketch showing the dimensions of commercial cisterns

The commercial version is dimensioned so it can be placed in a parking space. This is a convenient size that allows extra storage to be easily added or taken away as needs change. The residential version does not have the same constraint, so it is simply the most convenient size for basic household needs.

Water storage cannot be considered without piping; the water has to get from the storage facility to its ultimate use. Figure 4.19a shows the water storage and piping diagram. This diagram shows the locations of cisterns as blue dots and the storage lines as a blue arrow to indicate direction of flow. Water cisterns are located upslope from potential users to allow the pumping of water to be gravity-
assisted.



a: harvested water storage and piping

b: harvested water usage for on-site programs

Figure 4.19: Water diagrams for the harvesting scheme

Last, the water use diagram to the right in Figure 4.19b predicts the distribution of collected water within each building. The restaurants, boutiques, and retailers are likely to use the reclaimed water predominantly for toilet flushing, with part of the water being used for cooling towers. Lowe's in the top right is the exception. Because of the gardening center, irrigation is expected to be its largest use of reclaimed water. The residential unit numbers are based on the average Atlantan whose non-potable water use is roughly half toilet flushing and half irrigation[43]. Though the covered parking lot stores harvested water, it simply pipes its water to surrounding users.

Green roofs

A good portion of the site is covered in green roofs. These roofs each serve the purpose of reducing and delaying the amount of stormwater running off, as well as filtering whatever impurities may have been collected from the air. They also present a more aesthetic and intriguing view from the surrounding neighborhoods. In addition to the rainwater, most of the offsite water flows onto the roofs to receive treatment. The northern stormwater drainage flows onto the Target roof, the northeastern onto the Lowe's roof, and the southeastern on to the boutiques to the southeast. The roofs are all tilted facing upslope, so that water is stored at the highest possible point. An illustration of this concept is presented in Figure 4.20.

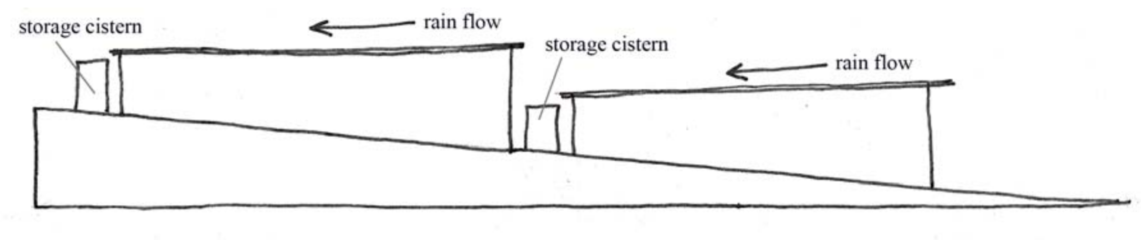


Figure 4.20: Roof configuration diagram demonstrating up-hill location of storage cisterns

Each individual roof benefits from being as large as possible to minimize maintenance and optimize the placement of cisterns. As a result development is clustered in large

[43] *Water Supply Basics*. Metropolitan North Georgia Water Planning District. 1/12/2008 http://www.northgeorgiawater.com/html/207.htm

chunks. After passing through the filtering medium of the green roof, the harvested water is then funneled into the corresponding cistern for later use.

With one exception all the green roofs on site are the thinner, and less costly, extensive variety. The one exceptional green roof is the over the Lowe’s store. Taking a cue from the Delft Library, the area above is a public park known as Lowe’s Park. Like Delft it has an intensive roof that allows for residents of the development and neighboring communities to enjoy. The surrounding topography is such that the ground along Marion Place is even with the height of the Lowe’s roof. Access from inside the site itself is through a stairwell just south of Lowe’s. A rendering of the park concept can be seen in Figure 4.21. The roof features a grass surface with brick water channels that aid in distributing off-site water as well as helping to break up the space visually. The image shows the steel cisterns off to the right as well as the fenced edge to prevent potential accidents.

Another portion of the roof component is the covered parking deck. Covered parking essentially brings the under-utilized underground parking in the existing development above ground. Not only does this make collection of stormwater easier, it also has the practical function of shielding those cars and that asphalt from the hot Atlanta sun. Because some of the townhouses look out over the parking lot, vegetative screening is included. A sketch of the screening can be seen in Figure 4.22.

Figure 4.21: Rendering of Lowe's Park Before (top) and after (bottom)

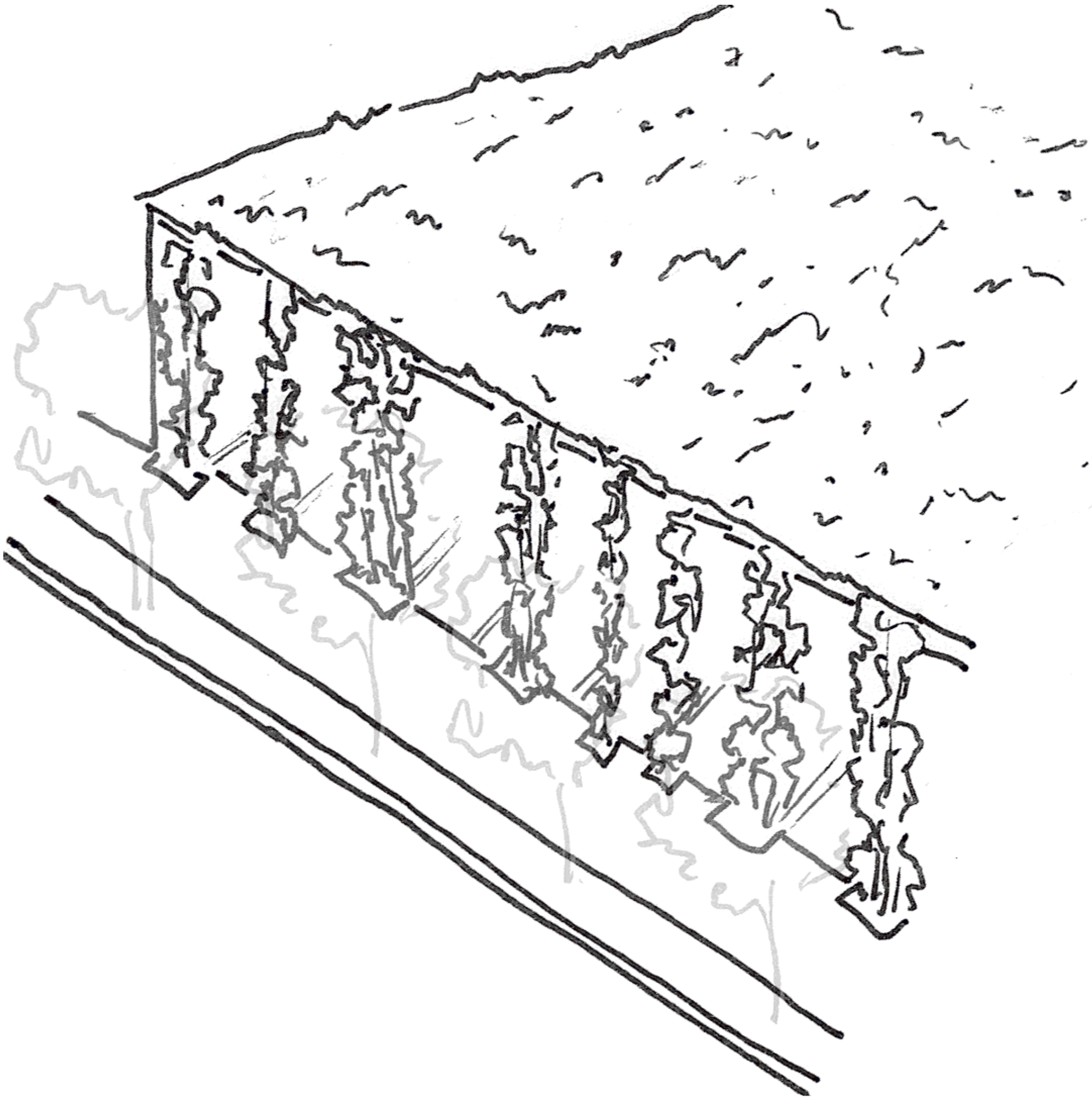
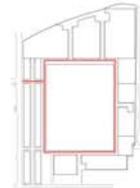
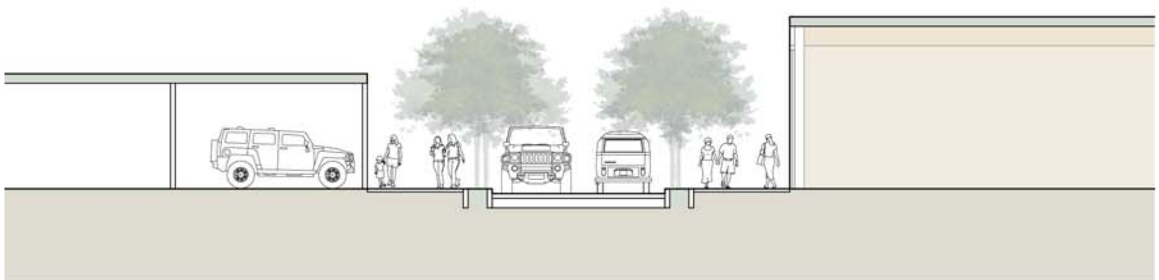


Figure 4.22: Parking screen sketch

<u>Lean Streets</u>

Like the infiltration scenario, the harvesting scenario cuts down on streets to avoid contamination. A simple loop with all the parking inside and programming on the outside provides all the access needed for freight, residents, and visitors. This





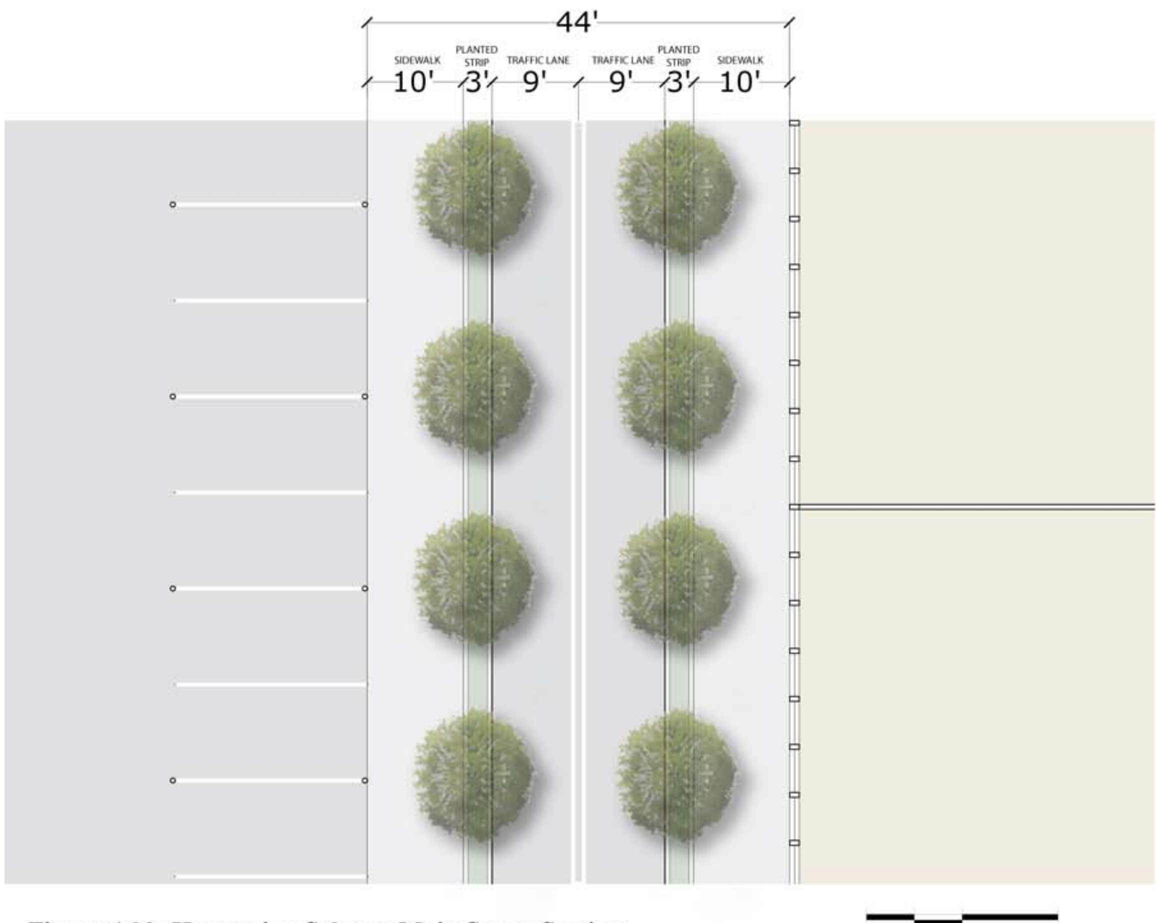


Figure 4.23: Harvesting Scheme Main Street Section

configuration can be seen in the site plan in Figure 4.17. There are two main roads on Moreland and two on Hardee St. The main entrance is the larger road to the north that connects to Seaboard Avenue. The second street on Moreland is smaller although it has a larger vehicle lane and curb radius to accommodate freight trucks. One of the streets off of Hardee is simply a continuation of the alley that serves the two rows of townhouses there. The last road off the site provides easier access to people to the east side of the site. There are three main road types in the development. The loop and the main road off Moreland have the most grand streets with narrow planting strips and two nine foot traffic lanes, this configuration can be see in Figure 4.23. Second, there is the freight access street off Moreland and the neighbor access off Hardee, both of these are smaller and lack planting strips to keep them as small as possible. They can be seen in Figure 4.24. The last street is really an alley, the diagram for which can be seen in Figure 4.25. Freight enters the site through the secondary Moreland entrance and moves counter-clockwise around the loop until it meets the access for the correct loading dock. Loading docks were cut into each major block of buildings to ensure delivery of goods to each store and make the loop street more pleasant.

Spreading the Program:

In contrast to the infiltration scenario, the harvesting scenario essentially required single-story development by requiring the maximization of catchment area. This was little to no change from the big-box retailers, but it had ramifications for the other programs. To stay under one large continuous roof the boutiques in the building between Target and Lowe’s are configured like a mall with internal circulation. Other blocks did not require much change. The dispersal of the program meant that the housing needed to be spread out. The housing off Moreland is configured as two rows of back-to-back two-story townhouses with front and back yards. This was because single-story townhouses are awkward and single-family houses took up too much room.

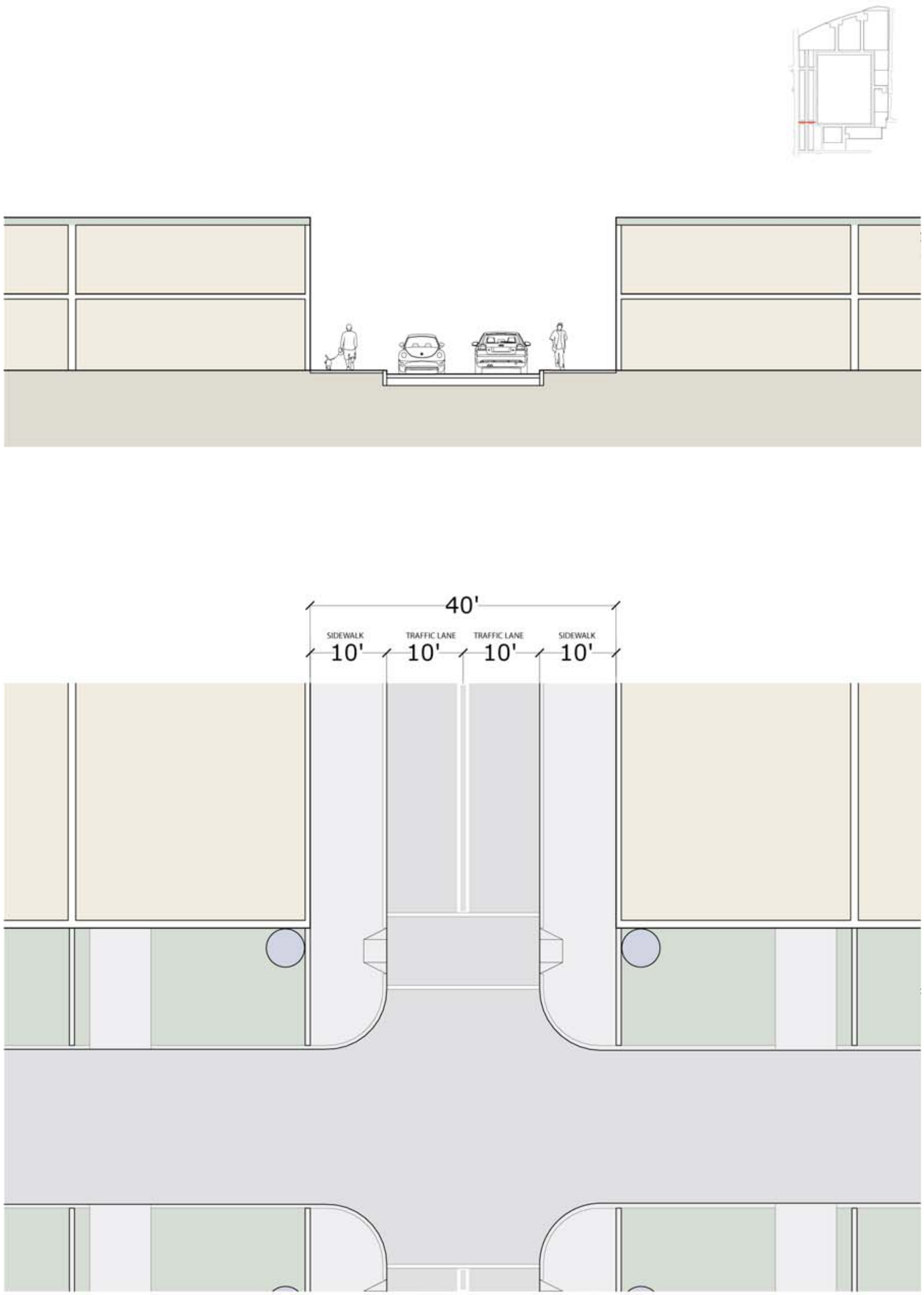


Figure 4.24: Harvesting Scheme Access Street Section

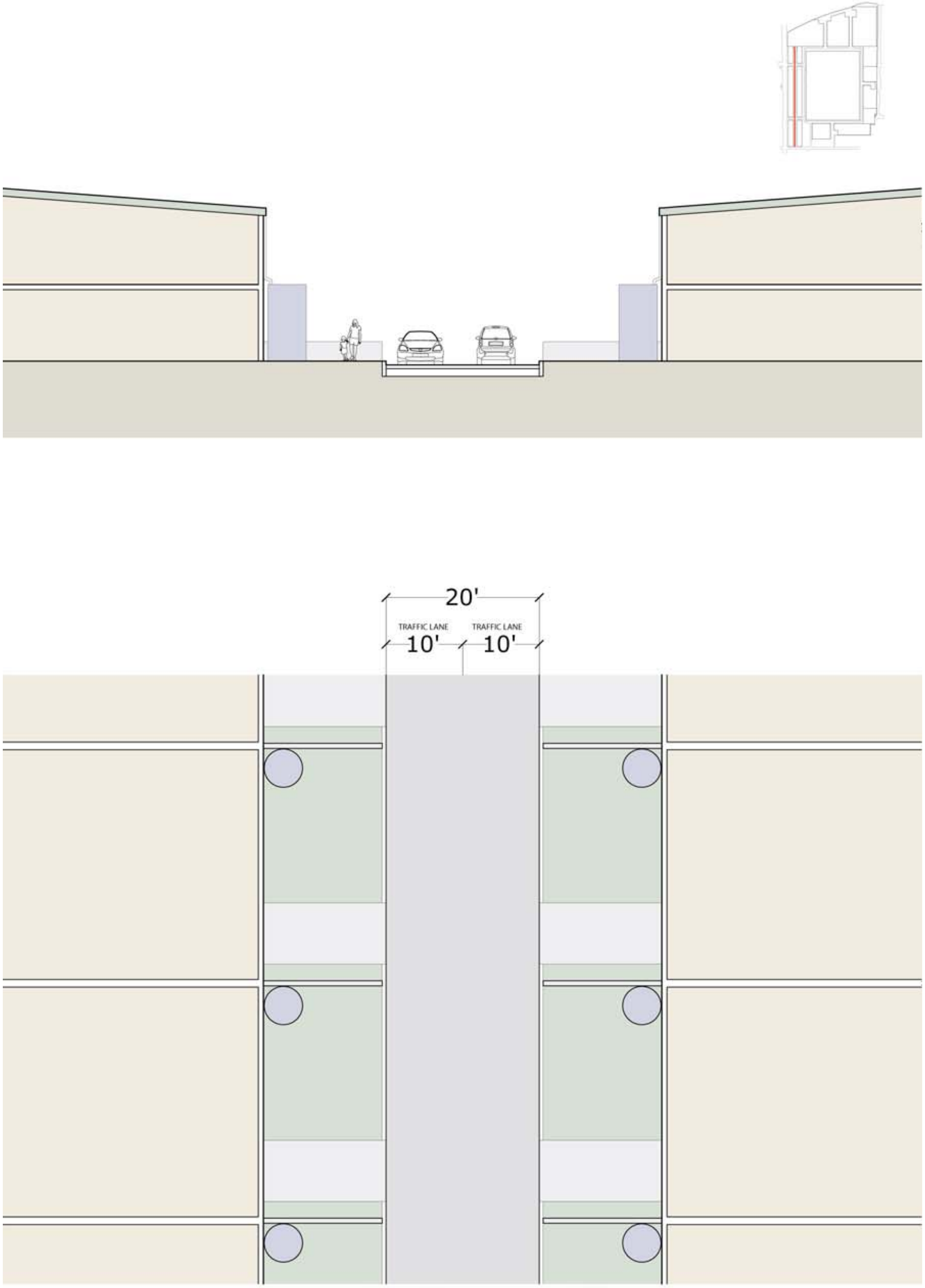


Figure 4.25: Harvesting Scheme Alley Street Section

Wetland

Because streets are a necessary part of the plan and they also collect pollution, there is some stormwater that will become contaminated. In this scenario this means that the contaminated water is not being harvested. Figure 4.26 shows the grading diagram, which also demonstrates the flow of water. The water flows around either side of the loop as it makes its way toward the low point in the south west of the site. Off-site stormwater from the western drainage area also drains into the street, adding a significant amount of water. To handle this contaminated water, a constructed wetland is between the retail building and Hardee Ave in the southwest corner of the site. The wetland has a small pond on either side to catch sediments and slow down the flow of water. Any overflow from the wetland is conveyed to Sugar Creek. Because small wetlands run the risk of drying out, harvested stormwater can be used to keep the wetland functioning in dry periods. The benefit of the wetland here is not only one of stormwater treatment but also one of aesthetics and wildlife habitat.

Sugar Creek Park

The grading diagram (Figure 4.26) also shows that water coming from the western half of the site flows over part of Sugar Creek Park. This portion of the park is designed to act as a kind of vegetated strip with a series of shrubs and more intense landscaping to slow and help pre-treat some of that water. The rest of the park is an open grassed area that allows for residents of nearby townhouses to relax or enjoy the park in a more active way.

Fitting the Harvesting Scenario Together

The connection between the individual components can be seen in Figure 4.27. Basically, the contaminated water from the streets or the western drainage is conveyed to the wetland for treatment. The rest of the water is cleansed and detained by green roofs

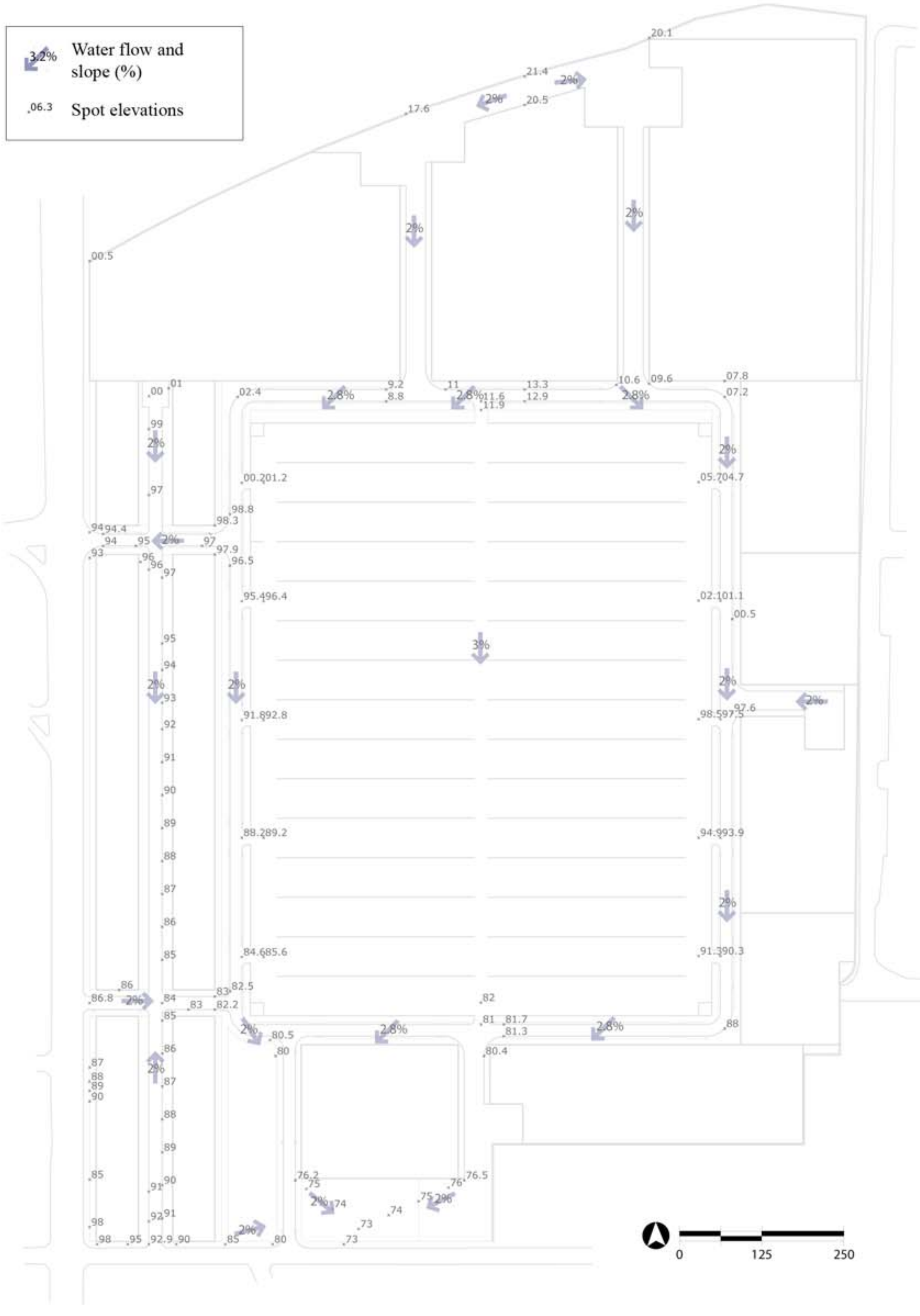


Figure 4.26: Harvesting Scheme Grading Diagram

before being stored in cisterns. Its eventual fate depends on its use. Irrigation results in infiltration, cooling uses cause the water to evaporate, and toilet fixtures convey the water through the sanitary sewer. Any water above what can be stored by the cisterns flows to the wetlands. In very large storms the wetland will overflow to the storm drain to prevent flooding of the site.

On an urban level the harvesting scheme has some faults, but overall seems to have more public space and interesting places. The site sections illustrate some of the connection between the different pieces of program. Figure 4.28a shows how the two rows of townhouses back up to one another and how they meet the streets on each side. Figure 4.28b shows the simple configuration of the parking as it relates to the shopping spaces. Figure 4.28c demonstrates how Lowe’s park relates to the store beneath it and the neighborhood above. The parking lot is very large, but to truly maximize the collection area, it is the most direct way. The pedestrian area is also diminished because parking prohibits stores on both sides. Despite its flaws, the scheme does provide two sizeable parks and a wetland for the enjoyment of the residents and neighbors. It also harvests a large amount of water, although how much remains to be seen in the next chapter.

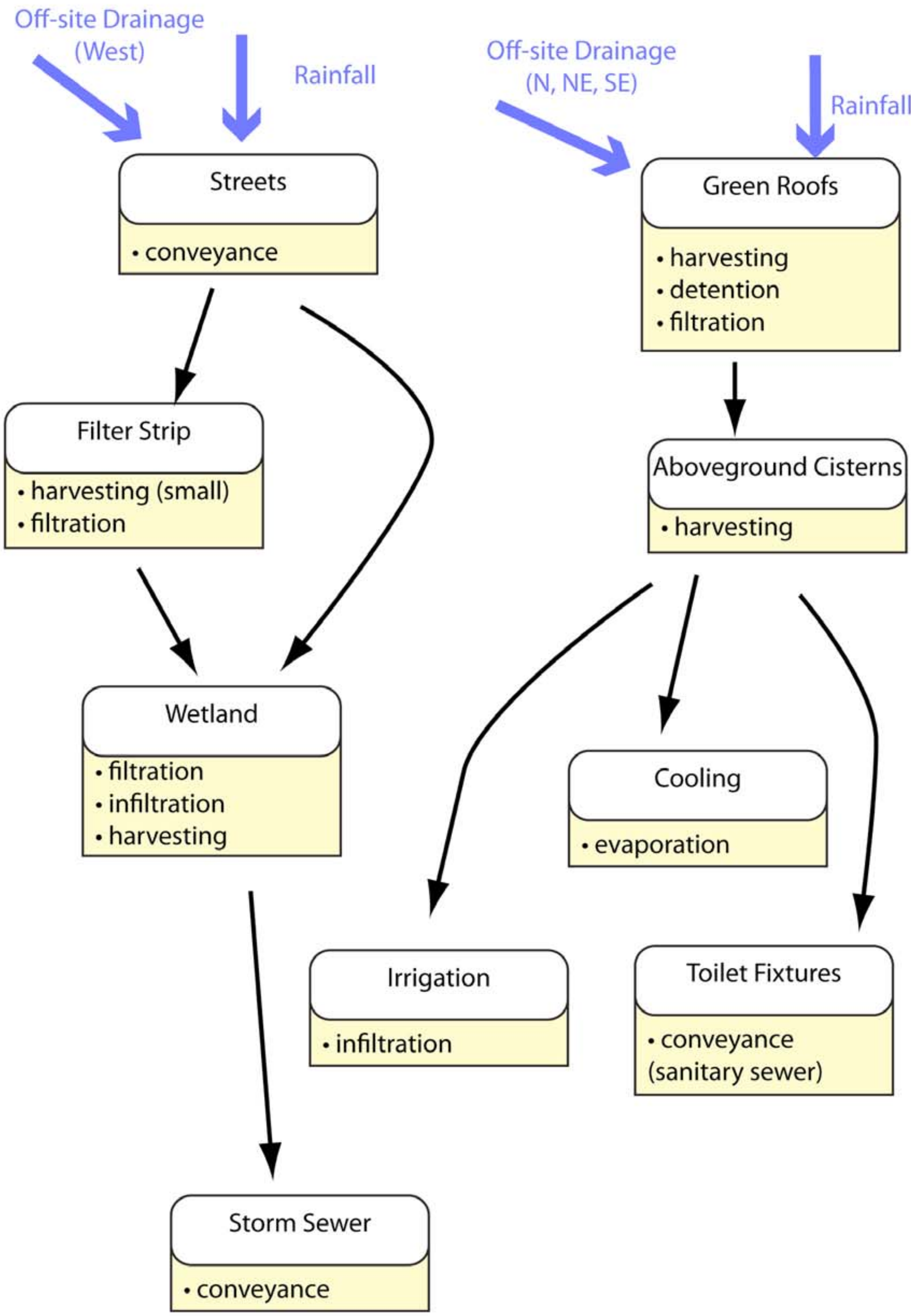
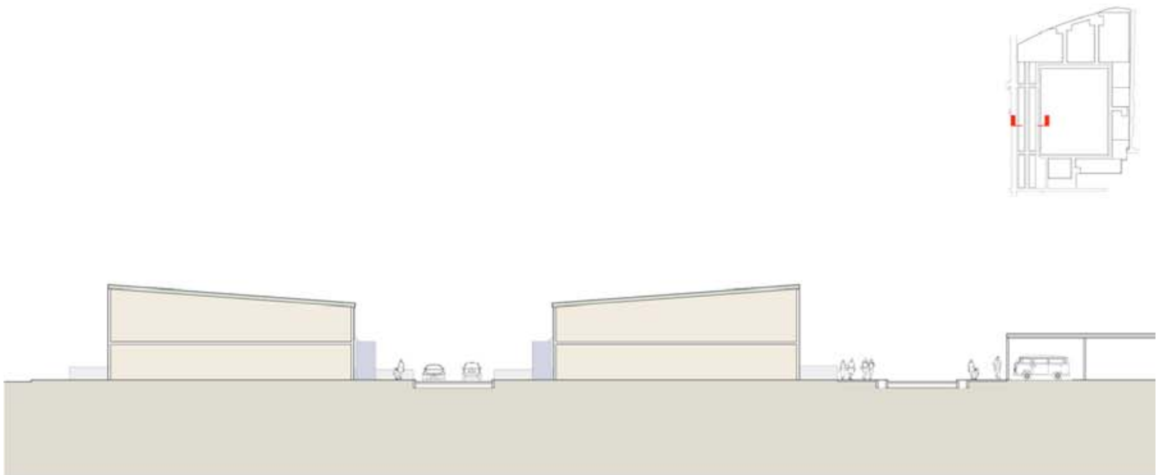


Figure 4.27: Harvesting Strategy Flowchart

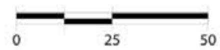
Stormwater Alternative Conclusions

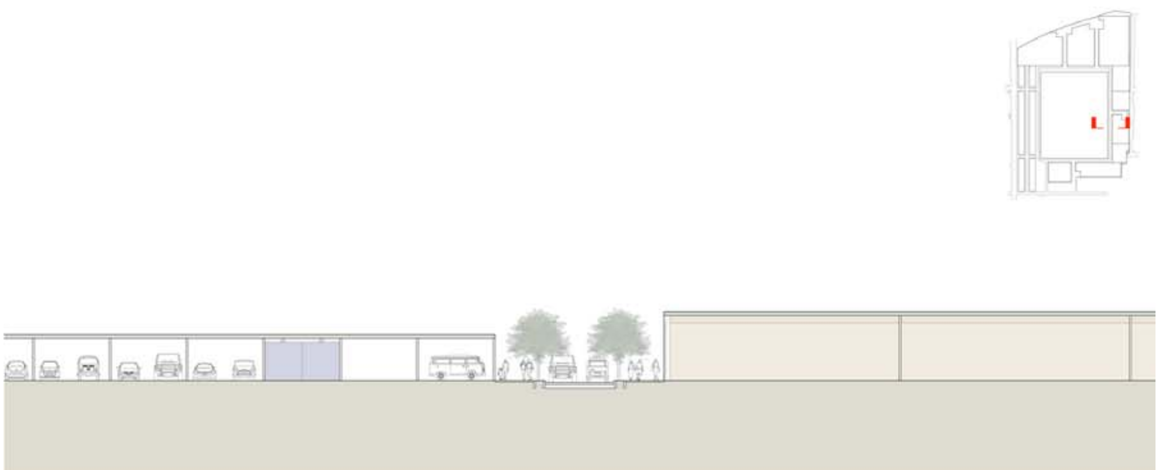
The two underutilized stormwater management principles, infiltration and harvesting, are explored in this chapter as alternative site-based strategies. Both strategies are pushed to their limits while keeping the same amount of program found in the Edgewood Retail District (ERD). The infiltration scheme maximizes permeable surface by moving the big-box retailers and associated parking inside multi-story buildings. The saved space is divided into numerous infiltration basins that also serve as park space. The various tactics used fit together to allow the water to flow from one to the next; conveyance only occurs as a last resort. The result is a holistic and integrated approach to stormwater management.

The harvesting scheme maximizes harvested water by spreading the roof coverage over as much of the site as possible. In addition all the roofs, including over the parking lot, are green roofs to help purify the collected water. The roofs collect the water in aboveground cisterns distributed throughout the site. The pieces of the harvesting system operating in concert treat all collected water for storage and filter and detain all uncollected water. Both sites manage to integrate their respective stormwater management principle into their site design effectively while maintaining the same program as ERD. The two schemes are compared to one another and to the Edgewood Retail District in the next chapter to determine how effectively stormwater management is altered.

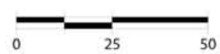


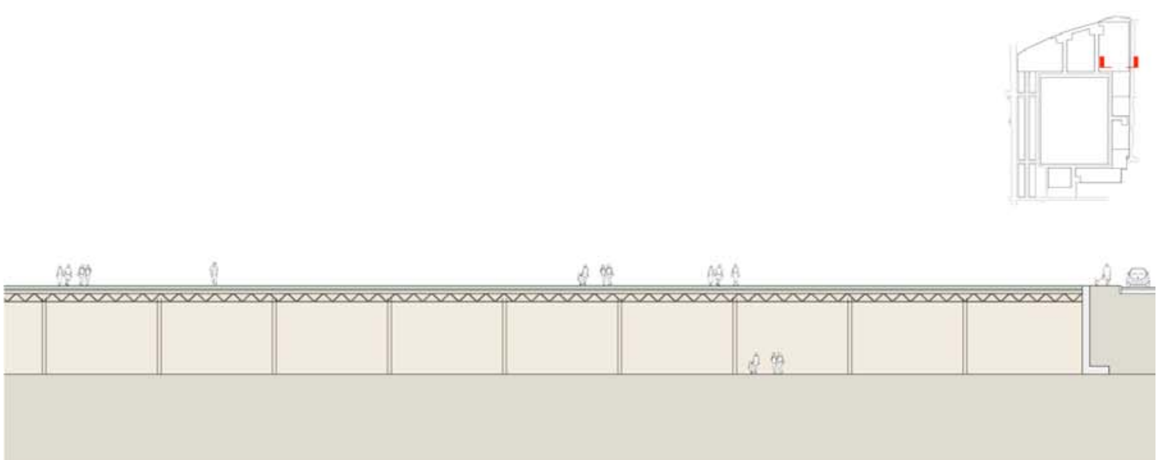
a: site section along bar of townhouses





b: site section between parking lot and commerical areas





c: site section through Lowe's Park

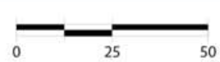


Figure 4.28: Harvesting Scheme Site Sections

CHAPTER 5

ANALYSIS

Chapter Overview

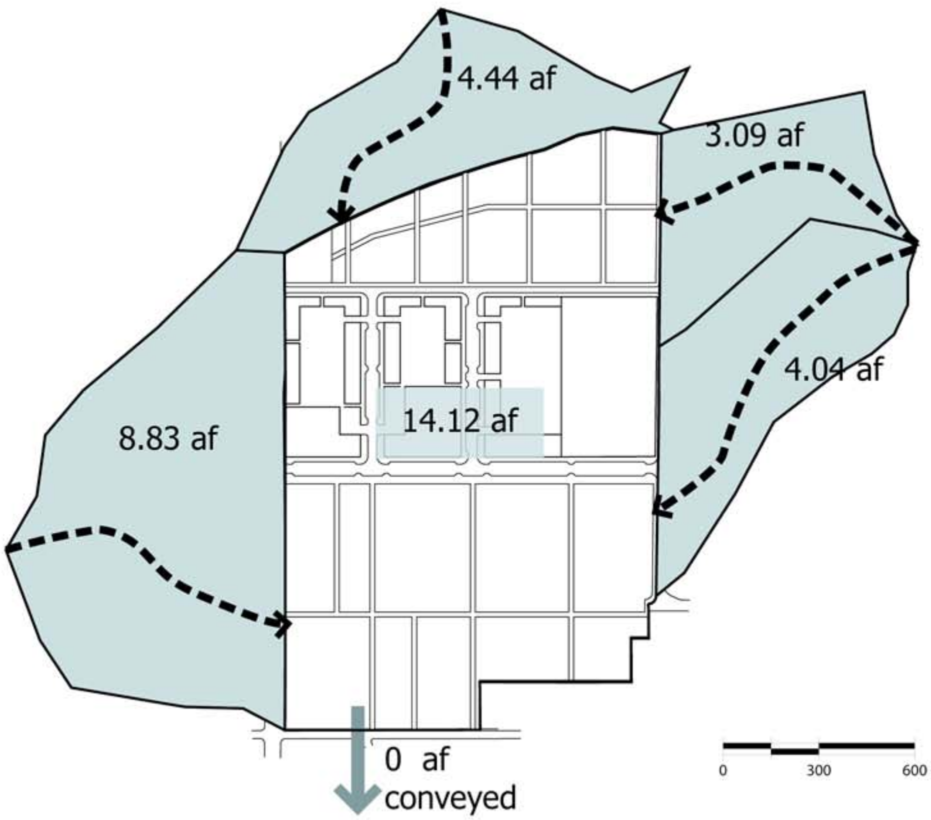
The last chapter laid out the components and strategies of the two designed alternatives to Edgewood Retail District, but did not compare them in depth. Each of these alternatives tests an under-represented principle of stormwater management in Big-box Urban Mixed-Use Developments (BUMDs) by pushing the principle to its limits. This chapter will examine the two alternatives against one another, as well as against the existing Edgewood Retail District. The basis for the analysis will be on several criteria to clarify and focus the discussion: stormwater, greenspace, municipal water, and urban quality. The results and corresponding discussion can give a clearer sense of the positives and negatives involved with each scenario.

Stormwater

Stormwater is important for judging the scenarios because it is one of the most noticeable environmental impacts of building BUMDs. It serves as another reason to deny or hinder big box development. Properly managing stormwater on-site in constructive and novel ways can reduce opposition, but it can also create quality places. This is in turn makes it more attractive to both tenants and shoppers.

Stormwater Analysis

To compare the different scenarios fairly, the stormwater analysis for the two alternatives must first be presented and discussed. As with the stormwater analyses of the existing and previous developments, the projects are measured by the use of the Soil Conservation Service (SCS) method, described in Appendix A. Both scenarios are set up as extremes to test the limits of a site strategy based on the corresponding stormwater



Infiltration					
name	drainage area(sf)	acres	Curve #	Qd	Volume (af)
rooftops	517,860	11.89	98	6.24	6.18 af
streets & sidewalks	221,707	5.09	98	6.24	2.65 af
green space	1,184,640	27.20	61	2.33	5.29 af
parking	0	0.00	98	6.24	0.00 af
subtotal	1,924,207	44.17			14.12 af
off-site drainage					
west drainage	926,939	21.28	87	4.98	8.83 af
north drainage	466,555	10.71	87	4.98	4.44 af
northeast drainage	324,760	7.46	87	4.98	3.09 af
southeast drainage	424,492	9.74	87	4.98	4.04 af
subtotal	2,142,746	49.19			20.41 af
grandtotal	4,066,953	93.36			34.52 af

Figure 5.1: 25-year SCS Calculations and Diagram for Infiltration Scenario

management principle. The infiltration scenario aims to allow all of the water on the Edgewood site to percolate into the ground. The harvesting scenario aims instead to harvest as much water as possible without elaborate pumping schemes. The results and a short explanation of each scheme are presented below.

Infiltration

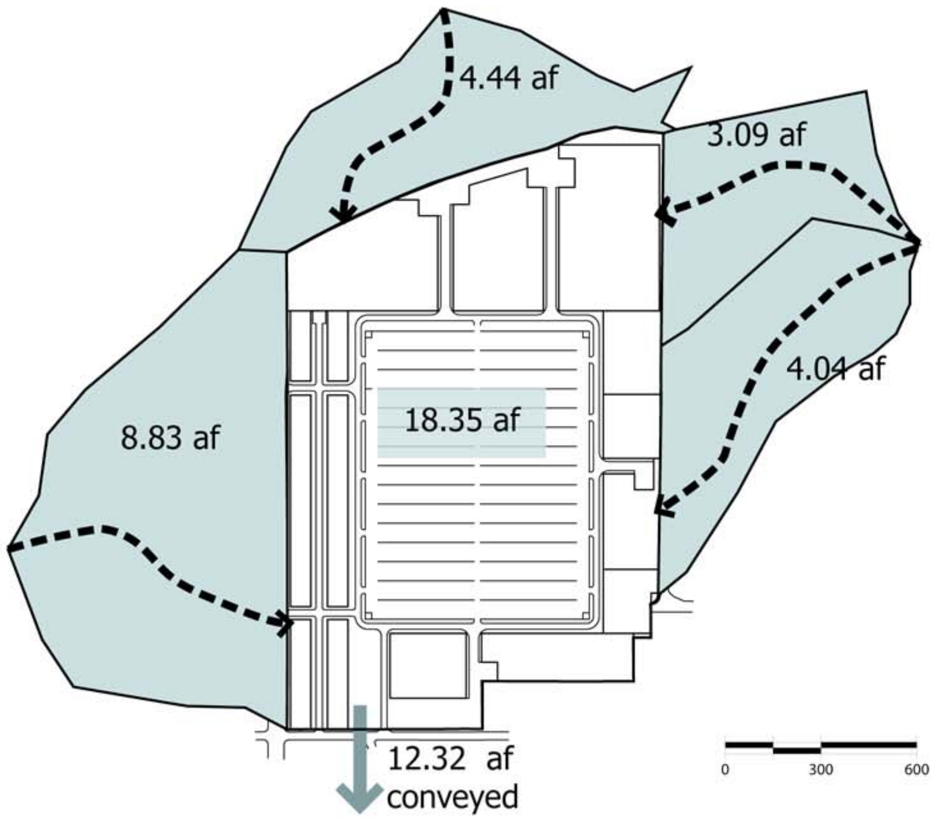
The results of the SCS analysis for the infiltration scenario are shown in figure 5.1. The off-site analysis has not changed, since this area is assumed to remain the same through all the scenarios. As with the analysis done in the site chapter, the curve numbers are referenced from Ferguson[44]. Note that the parking line of the table is listed as zero; this is because the parking is either in decks or on street, so it is already accounted in the roof and street coverage. The illustration above the table graphically demonstrates the volume of water generated by the areas off-site and how much stormwater the site generates. The individual components of the on-site stormwater are detailed in the table below. The arrow at the bottom of the illustration is the amount of water that is conveyed off the site into Sugar Creek.

Harvesting

The results of the SCS analysis for the Harvesting Scenario are shown in Figure 5.2. The table category labels and curve numbers differ from infiltration, for the simple reason that the qualities of these components have changed. The green roof absorbs some of the rainwater, which changes its curve number. Research indicates that green roofs have a curve number between 84 and 90, so an average of 87 was used[45]. Similarly the parking is listed as covered parking to distinguish the fact that it is covered in a green

---

[44] Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.
[45] *Green Roof Research Program*. Michigan State University Department of Horticulture. 1/02/08 http://www.hrt.msu.edu/greenroof/



Harvesting

name	drainage area(sf)	acres	Curve #	Qd	Volume (af)
green rooftops	915,500	21.02	87	4.98	8.72 af
streets & sidewalks	249,707	5.73	98	6.24	2.98 af
green space	115,000	2.64	61	2.33	0.51 af
covered parking	644,000	14.78	87	4.98	6.13 af
subtotal	1,924,207	44.17			18.35 af
off-site drainage					
west drainage	926,939	21.28	87	4.98	8.83 af
north drainage	466,555	10.71	87	4.98	4.44 af
northeast drainage	324,760	7.46	87	4.98	3.09 af
southeast drainage	424,492	9.74	87	4.98	4.04 af
subtotal	2,142,746	49.19			20.41 af
grandtotal	4,066,953	93.36			38.75 af
			harvested		26.43 af
			unharvested		12.32 af

Figure 5.2: 25-year SCS Calculations and Diagram for Harvesting Scenario

roof. As a result it uses the same curve number of 87. The two lines at the bottom of the figure list the harvested and unharvested quantities. The unharvested quantity is the total of the west drainage, whose elevation was too low to capture, and the streets, which are a source of contamination. This water flows to the wetland and from there to the storm drain that leads to Sugar Creek. The actual effect of the wetland on stormwater quantities is unknown and highly dependent on the final design; as a result it is assumed to have no impact for this analysis. All the remaining water is collected for potential use.

The second dimension of the harvesting scheme is storing the water. To store the 25-year storm requires 18.35 acre-feet of storage, which requires a large number of the proposed cisterns. At ten feet tall, it would require 509 parking spots to fit the required cisterns, covering an area just under that of the interior mall. Even if twenty-foot cisterns were used, the required area would still be slightly larger than the commercial building north of the wetland. This represents a substantial amount of space for simple water storage.

Comparison

It is possible to compare the three scenarios against one another now that the stormwater analysis of the alternative scenarios is complete. The generation of stormwater for the 25-year storm varied considerably across the three scenarios, as seen in Figure 5.3. Harvesting diminishes the water conveyed off site to less than 30% of what it is currently. However, if you discount the harvesting portion it only diminished the on-site stormwater by 20%. This seems like fairly little considering the minimization of pavement and extensive use of green roofs. During the 25-year storm the infiltration scenario manages to keep everything on site. Part of the reason is that green space can infiltrate more than green roofs; you only need to look at the curve numbers to see that green roofs are not as effective as grassed spaces. Dense vegetation has even lower curve numbers and has the potential to be implemented in creating more efficient infiltration areas. The infiltration basins can easily handle the 25-year storm and can even go a bit further; its 27 acres of greenspace can absorb quantities approaching the 50-year storm. This land area represents more than 60% of the site, which any developer is unlikely to accept without an excellent reason. Whether or not this is too much devoted space depends on the ultimate stormwater goal.

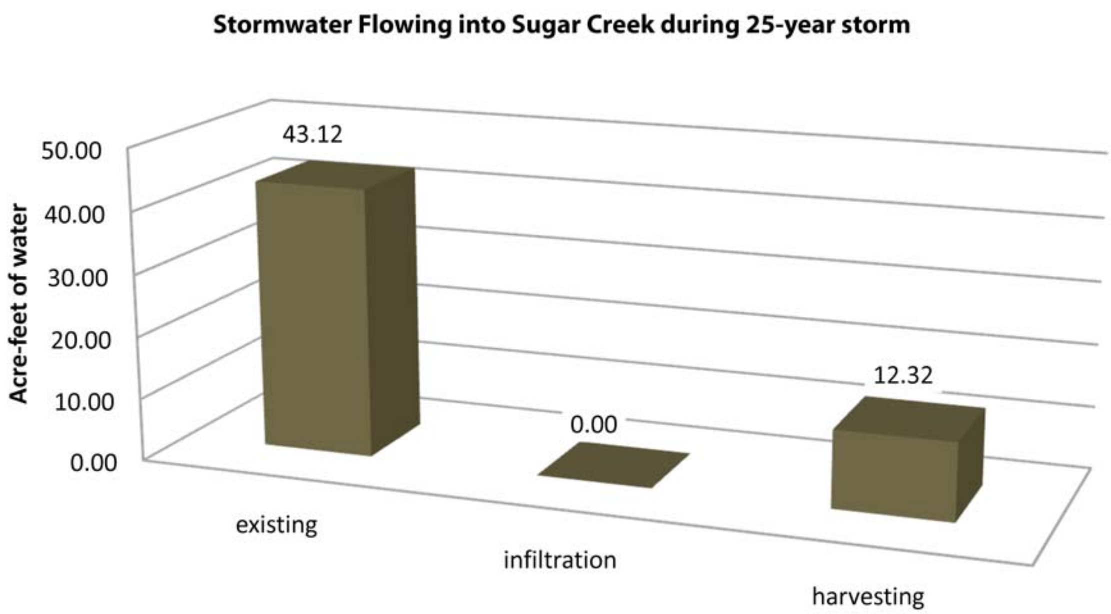


Figure 5.3: Stormwater exiting the site during 25-year storm

If groundwater recharge and a more balanced stormwater management plan are desired, then far less space is necessary. If the 1-year storm (3.4 inches) were infiltrated, it would represent more than 95% of the total volume of water falling as rain[46]. To do this for on-site and off-site generated water would require 9.83 acres to infiltrate, a quantity that represents 22.3% of the site. This 22.3% is less than all of the usable open space requirements required by Atlanta's Land Use Intensity (LUI) Ratios; a development the

---

[46] Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.

size of ERD would have a requirement of close to 40%[47]. This suggests that many developments in Atlanta are already required to have outdoor space in excess of what is needed to infiltrate the 1-year storm. Recall that since this site is located in a former stream bed, it receives an unusually large amount of stormwater from off-site, so locations outside of a streambed could conceivably make due with even less space. The main caveat is that the success of infiltration is based on its soil, and not all soils are capable. In particular the clay-rich soils in Georgia can pose a problem, but a soil test yields a site-specific answer. Managing for water quality is also possible by infiltrating small volume storms, since these would also capture the extra-polluted first flush. Care needs to be taken to cleanse the first flush through the use of a bioretention area or similar configuration to avoid groundwater contamination.

On the other hand, if the site is designed for the 1-year storm, everything above that amount is conveyed off-site. The 25-year storm is not that infrequent and the ERD generates a large amount of stormwater during a storm of that size. A compromise between the 1-year and 25-year storms may be more reasonable. The Victoria Park example infiltrates the 5-year storm, so that may be a good indicator for a realistic balance. To infiltrate the 5-year storm would require 16.24 ac, representing 36.8% of the site. This number represents an area just under the 40% usable open space requirements for a development similar to ERD; larger requirements would force a more extensive rearrangement. It is possible to incorporate a significant amount of infiltration into developments by leveraging the open space in conventional designs.

Another consideration is that the city has been debating a stormwater utility, which would require property owners to pay for the quantity of stormwater leaving the

---

[47] *City of Atlanta Code of Ordinances*. Municode. 3/1/2008. http://www.municode.com/Resources/gateway.asp?pid=10376&sid=10

site[48]. This collected fee is an attempt to internalize some of the negative externalities caused by stormwater. The implementation of the stormwater utility may sway the decision towards infiltrating a larger storm.

BUMDs tend to have a dearth of green space while also causing stormwater issues. Infiltration can help solve both these issues by incorporating with public space and landscaping. These need not be large installments; infiltrating bioretention planters demonstrated in the infiltration scenario and in Portland's Green Street Program are good examples of infiltration in urban areas without large space requirements.

Greenspace

Though the term has many uses; greenspace is used here to mean vegetated space that is thoughtfully designed. It does not have to be park space, but it is designed space. Vegetated planters and landscaping are included in this grouping. Even though these areas are not usually designed for inhabitation, the presence of well-designed non-park greenspace can make a noticeable effect on the quality of any space. Greenspace is important to examine because the lack of it often a hurdle in negotiations of neighborhoods with developers. It makes development more appealing and draws bigger crowds. Additionally it can assist in meeting on-site stormwater needs, in a very appealing way.

The quantity of park greenspace varies greatly between the different scenarios, as shown in Figure 5.4. Infiltration leads the group, and with its waterway and infiltration room design, the quality of the greenspace also seems high. The spaces provided there provide for a lot of different activities. Realistically, it is unlikely that a developer would pay for such an expense and even if they did, the maintenance is an issue. If

[48] Clean Water Atlanta Stormwater Utility Planning Process. Clean Water Atlanta. 3/25/08 http://www.cleanwateratlanta.org/Stormwater/PlanningProcess.htm retrieved

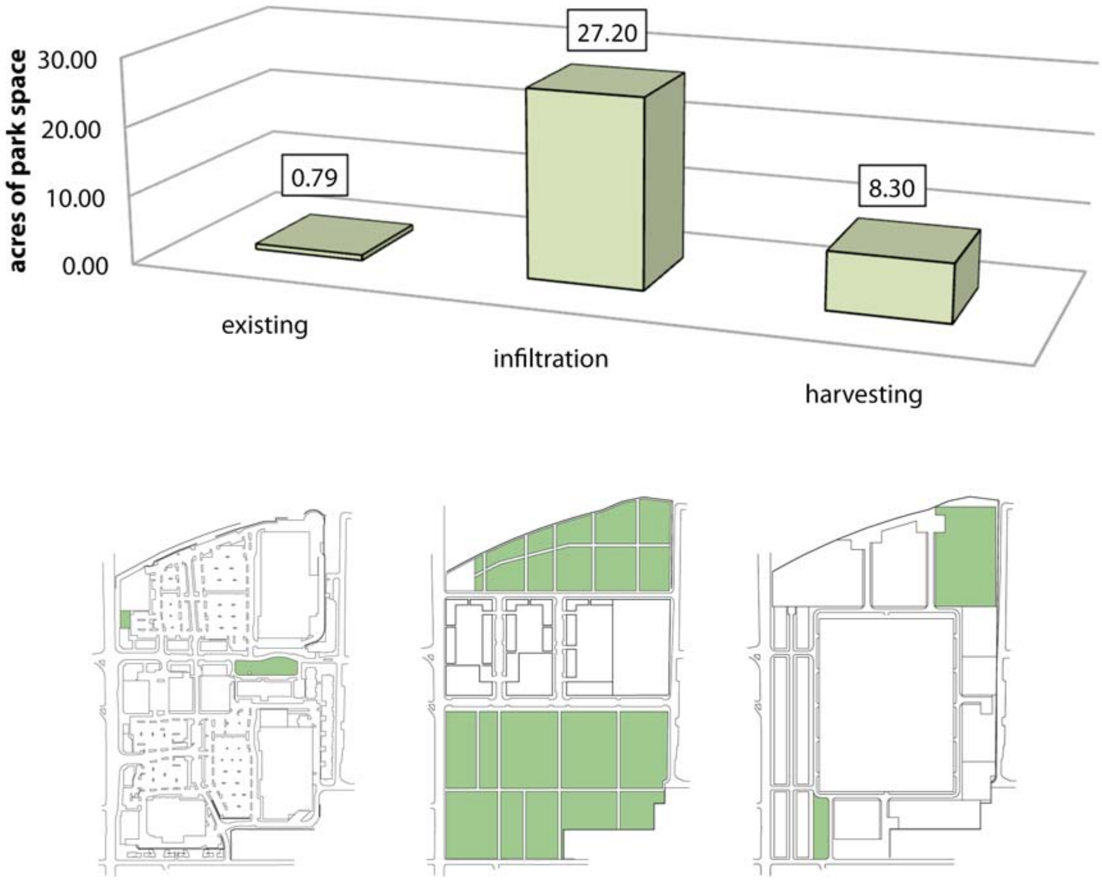


Figure 5.4: Park space comparison

implemented, funding the maintenance of the park space may be slightly easier because it also provides an additional stormwater service.

The harvesting scheme's green space has two main components: Lowe's park and Sugar Creek Park. Lowe's park provides an interesting twist on traditional parks by being on the roof and allowing a top-down view of the development. Sugar Creek is more residential, owing in part to its proximity to the townhouses there. Both parks provide quality open space and are large enough to accommodate several uses, but unfortunately they do not connect very well to the rest of the site. They are located off to the periphery, which makes them closer to the neighborhoods and the housing on site, but does not tie them in to a holistic scheme for the entire development. Including detention and or infiltration areas could have improved the stormwater performance of Sugar Creek Park, but it compromises pushing the limits of harvesting.

ERD has almost nothing in the way of greenspace. There is little recreational space in the development, active or passive. It has a planting strip along Caroline St. as well as some generic landscaping around some of the buildings. The largest piece is the lawn in front of the shoe factory lofts that is largely a space to be viewed. The second largest is the plaza by Best Buy, which feels contrived. Neither of the two areas is particularly connected to the rest of the development well enough to have any real activity. This may come with age, but thus far it seems to be a problem of design. The condition at Edgewood illustrates that it is not enough to simply have green space; it has to be done well to attract people.

Municipal Water

The examination of municipal water seems to be an unfair advantage for the harvesting scenario, but the issue of water is an increasingly important one in Atlanta. The Atlanta area currently uses 652 million gallons per day; that use is expected to grow by 300 million gallons per day in 25 years[49,50]. However, there are no additional major bodies of water to support the region, so scarcity is likely to increase. The current drought has highlighted this issue. Water conservation is likely to become more of a consideration in development over time. In this context, it seems beneficial to examine the special case of the harvesting scenario.

---

[49] *ARC Water Supply* Atlanta Regional Commission. 3/26/2008.
http://www.atlantaregional.com/cps/rde/xchg/arc/hs.xsl/273_ENU_HTML.htm
[50] *ARC Envision 6 Plan*. Atlanta Regional Commission. 3/26/2008
http://www.atlantaregional.com/cps/rde/xchg/SID-3F57FEE7-ECB9DDF2/arc/hs.xsl/126_ENU_HTML.htm

Determining the harvesting scheme's impact on water use requires some historical knowledge about the amount of water used by the development. Water usage data gathered from the city for the entire development over the two years from January 2006 to January 2008, serves this purpose (see Figure 5.5)[51]. The data fluctuates and there are some outliers likely due to the on-site construction that may have caused abnormal conditions. This data represents all municipal water usage, though only non-potable uses

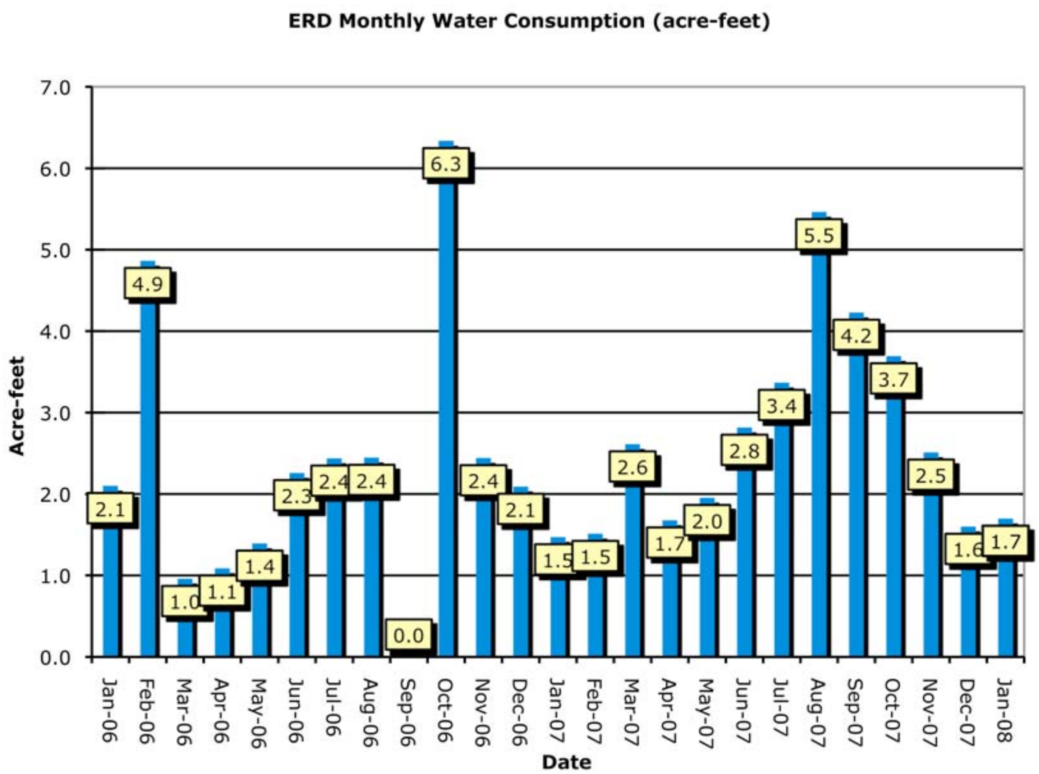


Figure 5.5: Water Usage data for the Edgewood Retail District

can be replaced with rainwater. For the purposes of calculation an assumption is made that approximately half of the total water use is for non-potable uses.

Data for the supply side is also needed to complete the picture. Rainfall data collected from the National Climatic Data Center provides data over the same period of

---

[51] Langston, Melinda. *Caroline St. Consumption report*. email to author. 2/5/2008

time as the recorded usage[52]. Note that drought conditions have persisted in the area since March 2006, which resulted in less total rainfall. Using Ferguson's monthly rainfall method described in Appendix A, this rainfall can then be used to calculate the volume of stormwater collected over the same period. Figure 5.6 shows a graph of the calculated harvested water compared to non-potable usage. The red area shows the non-potable water usage, while the blue is the water collected through the harvesting system, both in

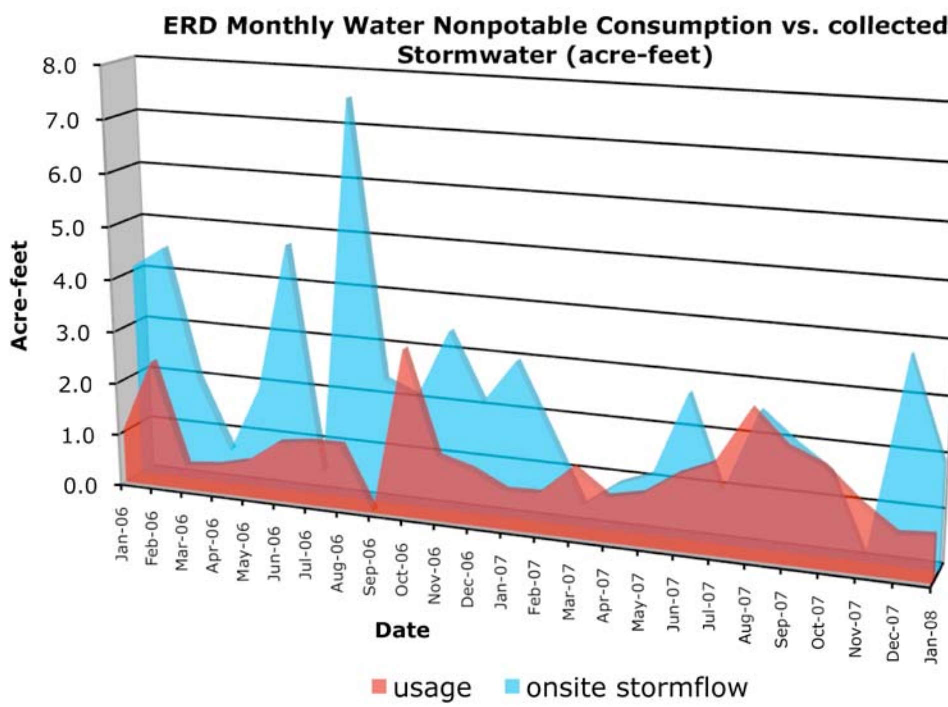


Figure 5.6: Historical Nonpotable Water Usage Plotted against Harvested Water

acre-feet. For comparison, Figure 5.7 shows a similar graph except that it shows the water harvested on-site only, it assumes the off-site water is not harvested. Figure 5.6 shows that most of the time the water collected at Edgewood could meet all non-potable

---

[52] *Atlanta Climate Summary*. National Climatic Data Center .2/2/2008. http://www.ncdc.noaa.gov/oa/climate/research/cag3/w5.html

demand. This is impressive since in 23 of the 25 months observed, the site is under drought conditions.

Storage to meet the 25-year storm certainly could cover all the site's non-potable water needs. However all the non-potable needs could be meet by a much smaller 3.6 acre-feet, requiring only 100 parking spaces for the ten-foot cisterns; 5 times less storage than the original proposal. To harvest those 3.6 acre-feet needed to meet all non-potable demand would require only 6.92 acres of roof space, which is less than the 12.47 acres present in the existing development, and 11.88 in the infiltration scheme. Harvesting does not need to be maximized to meet non-potable water needs. Since unharvested water is conveyed off-site, storing just 3.6 acre-feet would result in 35.15 acre-feet of water

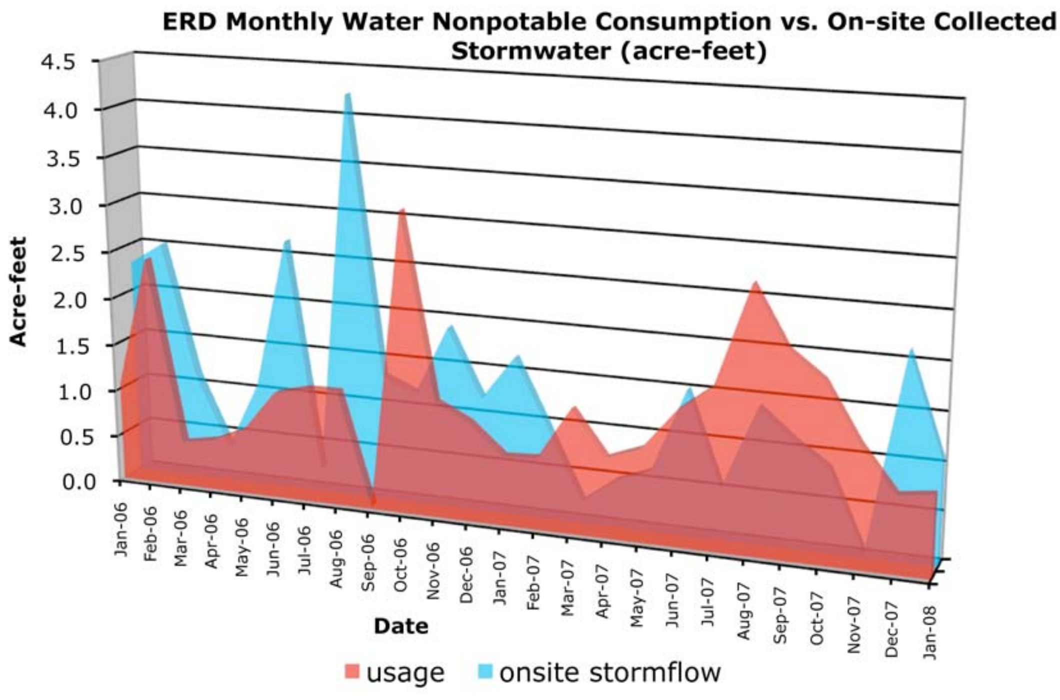


Figure 5.7: Historical Nonpotable Water Usage Plotted against On-site Harvested Water

flowing off the site during the 25-year storm. This number is low because it assumes that the cisterns are empty when that storm happens.

There is a trade-off between reducing the stormwater going off-site and the practical quantity of water storage. This is demonstrative of the limits of harvesting; it is not really feasible as a solitary stormwater solution except for under special circumstances. Its ability to displace municipal water need is worthy of attention.

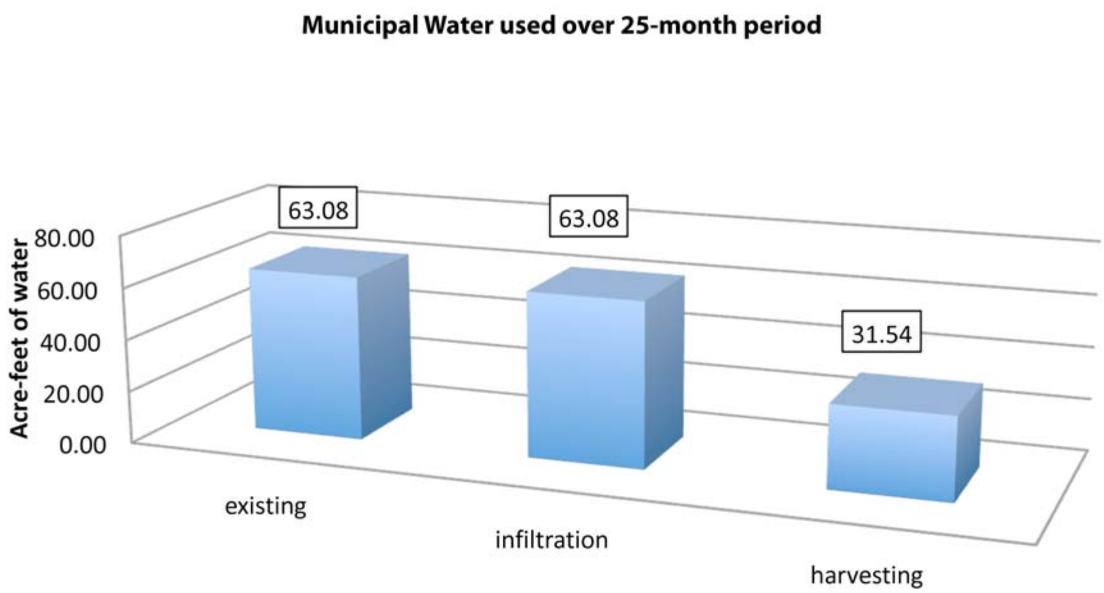


Figure 5.8: Municipal water use comparison

Urban Quality

The quality of urban environments is important for big-box developments for the simple reason that it helps attract tenants and visitors to the site. The main criterion here is whether these developments create spaces for civic life.

Infiltration shines in this criterion as well, as its park space integrates with the rest of the site through a series of paths that serve as both water infrastructure and public space. However, the abundance of park space actually hurts the development some, as the park is large enough to seem comparatively empty to the areas surrounding it. Additionally the buildings' park frontage as a normal condition diminishes the creation of enclosed space. The density of the parking, stores, and residences means that there is likely to be lots of activity on the streets around each building. Moving parking inside decreases stormwater as well as creating a more interesting street view and pedestrian experience. This density does bring a higher price to the development, that would need to be justified somehow, whether through the addition of more program or increased numbers of visitors. Both alternatives, despite their configurations, have streets designed for pedestrians. Some evidence of this includes the standard ten-foot sidewalks, the planting strips in all but a few examples, and the provision of on-street parking.

Edgewood Retail District does a fair job of creating an urban location along the pedestrian corridor. It includes planting strips, street furniture, on-street parking, and multi-story buildings to define the space. The only problem is that the corridor is so short. The majority of the program is not related to the corridor at all, since it is the typical big-box configuration. The large quantity of parking hurts the development, especially relative to the infiltration scheme, which benefits greatly from hiding the parking out of sight. The large surface parking lot serves as a deterrent for pedestrians; it is a wide gulf of unpleasant space that is rather avoided.

The harvesting scenario, like ERD, suffers from an excess of parking. In the harvesting example the parking dominates the center of the site. It makes a development where nothing is close together. Also, it loses the benefit of having true mixed uses; all the housing is along one corridor. At least Edgewood has some condos above the retail on the pedestrian corridor. Though the streets sections are meant to encourage pedestrians, the spread out nature of the harvesting site means that the sidewalks may not get as used as the vehicle lanes. The park space is quality space, but it is disconnected from the rest of the site.

Analysis Conclusions

Stormwater, greenspace, municipal water use, and urban quality are the criteria used to evaluate the different schemes. The stormwater analysis shows the alternative strategies generate a fraction of the stormwater run-off generated by Edgewood Retail District (ERD). In the case of greenspace the infiltration scheme as well as the harvesting scheme provide significant amounts more than ERD. Harvesting was the only scheme dealing with municipal water, but it was able to easily meet the nonpotable water needs of the site even during drought conditions. Modest amounts of storage are able store this amount, but limiting collection to nonpotable needs results in more stormwater run-off. From an urban quality standpoint, infiltration created true urban spaces, as well as interesting park space. Harvesting was very spread out, but resulted in some amenities not present in ERD. In all the criteria the alternative designs performed well against ERD, managing stormwater more effectively and providing new amenities. Now that the potential of each scheme is better known the implications for BUMD design will be described in the next chapter.

CHAPTER 6

CONCLUSIONS

Chapter Overview

The purpose of this study has been to demonstrate that stormwater techniques can be successfully incorporated into Big-box Urban Mixed-use Developments. The two scenarios tested, infiltration and harvesting, perform well from a stormwater perspective and in the process they add potential amenities to the site not there previously.

Recommendations

Of the four stormwater principles; conveyance, detention, infiltration, and harvesting, BUMDs only use conveyance and detention to handle their stormwater. The challenge is determining ways to incorporate infiltration and harvesting into these developments. The stormwater problems caused by Big-box Urban Mixed-use Developments are inherent to their typology: large roofs, surface parking, and the lack of vegetated areas. There are two paradigms to deal with the problem of stormwater in BUMDs: use existing configurations and make small but significant changes, or change the configurations to more completely manage stormwater.

Maintaining Existing Configurations

Creating big-box developments that integrate stormwater strategies is possible given existing configurations. First, provided with adequate soils, a relatively small amount of space can infiltrate one- or two-year storms fairly easily. The 22-30% of the Edgewood Retail District (ERD) site necessary to infiltrate the 1- or 2-year storms respectively is less than the City of Atlanta 40% usable open space requirement for the existing development. These small spaces of infiltration can be dispersed throughout the site in bioretention islands in parking, bioretention street planters, landscaping associated with buildings, and through utilizing existing usable open space requirements.

Second, harvesting of stormwater for nonpotable uses is also possible, through simply connecting roof drains to storage of some kind. Storing all the water is not necessary, but any quantity stored can displace municipal water use. Harvesting the 3.6 acre-feet needed to meet all non-potable demand would require only 6.92 acres of roof space, which is just 55% of the roof space at ERD.

A third simple change is the addition of green roofs. They do not change the configuration of space, but they can help detain, filter, and diminish stormwater.

Last, the use of roofs and parking lots as multi-use detention facilities would help. They would be able to detain water long enough to provide bioretention areas with a more gradual stream of stormwater. This would result in less stormwater flowing off site.

To work effectively a cohesive strategy should organize the individual elements to flow from one to the next. To minimize stormwater run-off this strategy should use conveyance as a last resort. These smaller solutions would be able to significantly decrease stormwater run-off during smaller storms and help with water quality and groundwater recharge. While incremental solutions address stormwater concerns they leave aesthetic and urban design concerns largely untouched. In choosing the incremental approach, developers miss out on an opportunity to address several concerns at once.

Innovating New Configurations

More extensive stormwater strategies involve redesigning the configuration of BUMDs from the ground up. All of the strategies discussed above for minor changes are relevant, but larger changes are more effective. Concentrating big-boxes into multiple stories and creating parking decks can free up space for parks. These parks can serve as infiltration basins at the same time. Rather than smaller design storms these sites can infiltrate larger storms, somewhere between the five- and twenty-five-year storms. The

40% open space required by City of Atlanta code can infiltrate the 5-year storm, though larger storms require specialized space. At the high end, an extensive park system is needed to accommodate the stormwater; the 25-year storm requires 24.22 ac, 54.8% of the ERD site.

Harvesting can be handled through underground cisterns, which could easily handle non-potable needs. More ambitiously, larger amounts of harvested water could be piped to surrounding sites for their nonpotable uses.

As above, the synergy between the parts is more important than any one individual element. Having a chain of treatment that moves through multiple elements before flowing off site automatically provides a more redundant and integrated approach to stormwater.

Though stormwater can be viewed as a separate problem from urban quality and aesthetics, they often overlap in the case of big-box urban developments. It seems practical to invest where efforts can deliver results for both pedestrians and for stormwater. Some of these more substantial changes involve additional time, labor, funds, or some combination thereof. A more detailed business case is needed to justify the increased cost. However, some of the cost may be offset from potential savings elsewhere or the potential for increased popularity and profitability of the site.

Next Steps

The next logical step is more in-depth study of the blended stormwater strategies in BUMDs that may be more immediately appealing to developers. These strategies would be examined closely with regard to their stormwater generation, cost, and urban qualities. The ultimate goal would be a buildable scheme for which a business case can be made. Another point of interest is the retrofitting of existing big-box developments. Further studies could explore whether sites can overcome the limitations of the existing frameworks. Whether it can be done in a cost-effective manner is also crucial. Local governments could also assist in promoting more water-sensitive BUMDs. Their role would be most relevant in creating more pertinent measures of stormwater and devising how meeting new standards could be met through a system of incentives and deterrents. As concerns about water management in urban areas grow, it seems likely that stormwater-sensitive sites are likely to increase. Providing a variety of valid approaches and incentives for water-sensitive developments would be helpful in managing stormwater water throughout these regions.

APPENDIX A

STORMWATER CALCULATIONS

SCS Method

The method used here is adapted from Ferguson[53]. To get the depth of runoff for a given area in inches, Q_d, the following formula is used.

$$Q_d = \frac{(P - I_a)}{(P - I_a + S)}$$

P = depth of 24-hour rainfall in inches

I_a = initial abstraction, what water is infiltrated or adheres to surface depressions before runoff begins. 0.2S is a commonly used value and is what was used for this paper.

S = potential maximum retention after runoff begins. This is derived from the curve number. The curve number in turn represents the ability of the soil to retain water and is based on land use and soil type. S is found through the following formula, where CN represents the curve number:

$$S = \frac{1000}{CN} - 10$$

Given these conditions the original formula can be written more succinctly:

$$Q_d = \frac{(P - 0.2S)}{(P - 0.8S)}$$

Q_d for each area is calculated by using the design storm depth in inches for P and the S value derived from each areas corresponding curve number. For this study values for the

---

[53] Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.

design storm were taken from the table in the Georgia Stormwater Management Manual[54]. These values are then used in the following formula

$$\frac{Q_d}{12} \times A = V$$

Where

A = collection area in acres

V = volume of stormwater generated in acre-feet

Monthly Runoff Method

This method is also derived from Ferguson but is suited for estimating runoff values from monthly rainfall data[55]. The following formula is used to find Q_d, calibrated for the Atlanta area

$$-0.161 + 0.235P/S^{0.64} < 0: \quad Q_d = 0$$
$$-0.161 + 0.235P/S^{0.64} \geq 0: \quad Q_d = -0.161 + 0.235P/S^{0.64}$$

where

P = monthly precipitation total, in inches

S = potential maximum retention after runoff begins, as in the SCS method

As above, Q_d is transformed to yield the volume V for a given area.

---

[54] Haubner, Steve, Andy Reese, Ted Brown, Rich Claytor, and Dr. Tom Debo. *Georgia Stormwater Management Manual*, 2001

[55] Ferguson, Bruce. K. *Estimation of Direct Runoff in the Thornthwaite Water Balance*. Professional Geographer, 48(3) 1996, pages 263-271.

REFERENCES

City of Atlanta Code of Ordinances. Municode. 3/1/2008. http://www.municode.com/Resources/gateway.asp?pid=10376&sid=10

City of Atlanta Comprehensive Development Plan 2004. 3/1/2008. http://apps.atlantaga.gov/citydir/dpcd/cdp/index.html

City of Atlanta, *City of Atlanta Department of Public Works Rules and Regulations Governing Development of Sanitary and Storm Sewers*. 1997.

City of Atlanta. *City of Atlanta Department of Public Works Department of Watershed Standard Details*. 2003.

City of Atlanta. *City of Atlanta Georgia Stormwater Management Design Manual*. 1996.

Ferguson, Bruce. K. *Estimation of Direct Runoff in the Thornthwaite Water Balance*. Professional Geographer, 48(3) 1996, pages 263-271.

Ferguson, Bruce K. *Introduction to stormwater: concept, purpose, design* New York : Wiley, 1998.

Ferguson, Bruce K. *Stormwater infiltration*. Lewis Publishers, Boca Raton 1994.

Ferguson, Bruce K.; Debo, Thomas N. *On-site stormwater management : applications for landscape and engineering*. Van Nostrand Reinhold, New York

Haubner, Steve, Andy Reese, Ted Brown, Rich Claytor, and Dr. Tom Debo. *Georgia Stormwater Management Manual*, 2001

Hinshaw, Mark. "Amsterdam opens a new culture park: Kathryn Gustafson transforms a Dutch brownfield into an amazingly complex landscape" Landscape architecture 2004 Nov., v.94, n.11, p.60,62-66,68,70-71

Hough, Michael. *Cities and natural process*. Routledge, New York 1995.

International Stormwater BMP Database. 3/1/2008.
http://www.bmpdatabase.org/index.htm

Koekebakker, Olof. *Westergasfabriek Culture Park: Transformation of a former industrial site in Amsterdam.* NAi Publishers.

Spirn, Anne Whiston. *The Granite Garden: Urban Nature and Human Design*. Basic Books, 1985.

Walesh, Stuart. G. *Urban Surface Water Management*. John Wiley & Sons. 1989.

Zaitzevsky, Cynthia. *Frederick Law Olmstead and the Boston Park System*. Harvard University Press. 1982.